State of Rhode Island and Providence Plantations.

# THIRTY-EIGHTH ANNUAL REPORT

OF THE

# COMMISSIONERS OF INLAND FISHERIES,

*Compliments of the*

*Commissioners of Inland Fisheries.*

PROVIDENCE:
E. L. FREEMAN COMPANY, STATE PRINTERS,
1908.

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MADE TO THE

GENERAL ASSEMBLY

AT ITS

JANUARY SESSION, 1908.

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## COMMISSIONERS OF INLAND FISHERIES OF RHODE ISLAND.

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# REPORT.

*To the Honorable the General Assembly of the State of Rhode Island and Providence Plantations, at its January Session,* 1908:

The Commissioners of Inland Fisheries herewith present their annual report for the year 1907:

The fact that the fishing in the inland streams and ponds of the state continues good, even though each year more persons are indulging in the health-giving and the delightful sport of angling, is due directly to the planting of fish fry and to the protection of the fishes by law. Of the present various activities of your Commission, the maintenance of the fresh-water fisheries within the state is the oldest, and has received constant attention for many years. Annually about 40,000 yearling trout are distributed throughout the waters of the state, and frequently black bass, shad and other valuable fishes are also planted. The efficiency of this procedure is unquestionable, and the beneficial results have enlisted the interest of the real sportsmen throughout the state so that they willingly coöperate with your Commission both in the distribution of fry and in the enforcement of the law. In order that there can be no excuse for ignorance of the regulations governing the fishing, the laws have been printed in convenient form for carrying in the pocket, and copies have been widely distributed and can be obtained at any time from the secretary of the Commission. During the past year 40,000 yearling trout have, as usual, been purchased and distributed.

The duties of your Commission do not pertain merely to the fresh-water fisheries, but extend also to the salt-water fisheries of the state. The latter, besides furnishing sport for anglers, are each year increasing in importance and in extent as a commercial industry.

The increase in the importance of the commercial fisheries is not by any means a local matter, but is general throughout nearly the whole world; witness the development of fisheries along the Atlantic and Pacific seaboards of the United States and Canada, the organization of the federation among the nations of northern Europe into a board of international fisheries, and the paramount fishing industry of Japan. Better organization, new and more effective methods, knowledge of the habits and movements of fishes, increasing facilities for distribution to markets, and the corresponding greater demand for fish food, and the realization of the immense possibilities of the fisheries in increasing the world's food supply are all factors in the development of this growing industry.

Within our own waters, some idea of the increase in the commercial fisheries during the past ten years can be obtained from a summary of the yearly census which your Commission has compiled regarding the number of fish traps set within the Bay and in the waters immediately outside. Leaving out of account the Block Island traps, the data are as follows:

| Year. | No. of traps. | Year. | No. of traps. |
|---|---|---|---|
| 1898 | 119 | 1903 | 195 |
| 1899 | 121 | 1904 | 214 |
| 1900 | 135 | 1905 | 234 |
| 1901 | 151 | 1906 | 243 |
| 1902 | 161 | 1907 | 265 |

The increase in the number of traps has been general throughout the Bay, though it has been greater in some localities than in others. This appears in the following summary:

| Year. | Prov. River. | East Green. | West Passage. | Mt. Hope Bay. | Sakonet River. | East Passage. | Off-shore. |
|---|---|---|---|---|---|---|---|
| 1898 | 4 | 6 | 26 | 9 | 34 | 15 | 25 |
| 1907 | 7 | 37 | 30 | 12 | 87 | 22 | 70 |

This increase in the number of fish traps serves perhaps as a fair index of the rapid extension of the commercial fisheries, but trap fishing is by no means the sole fishing industry. The alewives, herring, shad, flatfish, menhaden, cod, mackerel, sword-fish, and other fishes caught by means of seines, weirs, beam trawls, harpoons, and by the hook and line, figure conspicuously in the grand total of commercial fisheries.

Through enactment by the General Assembly several years ago, the lobster fishery was placed in the hands of this Commission.

Your Commissioners have faithfully endeavored to enforce the laws for the protection of this valuable but waning industry, and their endeavors have met with a gratifying degree of success. The majority of the lobstermen and dealers have been from the first in favor of the law and its enforcement, but there are, of course, some who systematically attempt to evade the law and thereby to gain an unfair advantage over their fellow fishermen by taking short or egg lobsters which honest fishermen put back into the water. The first effect of the enforcement of the law was a decrease in the catch, but since that time there has been yearly the steady increase which the advocates of the law expected and desired.

The present magnitude and the rapid growth of the fishing industry carried on in the public waters of the state must be of interest to your Honorable Body and to every citizen of Rhode Island. Wherever the fishing industry has attained considerable importance, difficult questions of legislative regulation have always arisen. The development of the fisheries, and not their restriction, should always be the motive in fisheries legislation. Restrictive measures are naturally the first to come to mind when the danger of exhausting a natural food supply threatens. While such measures are often warranted, even necessary as more or less temporary expedients, they should be applied with a reasonable care and not blindly, and they should be supplemented as far as possible with positive constructive measures looking to the actual further development of these resources. The history of oyster culture affords a simple and illuminating ex-

ample of the comparative value of restrictive measures and of developing the natural resources. Without restrictive measures the natural oyster grounds, once ample for all demands, would have been exhausted long before they were, but the present enormous output of oysters could never have been produced by merely restricting the fishing.

The problems to be solved differ with the different kinds of fisheries; but there are so many examples of the development of a particular branch of the fishing industry that it seems certain that in other branches the difficulties may be overcome one after another. Experience clearly shows that the first step toward permanent improvement of a branch of fishing industry consists in finding out the habits, food supply, movements, and general conditions of life, of the species in question: That the Federation of Fisheries Boards in northern Europe is occupied with the systematic study of the general conditions in the ocean from the English Channel to the Baltic Sea shows the general recognition of this fact.

While the problems of the development of the fisheries are too numerous and complex to be solved by any one country or state, or in any one generation, your Commission begs leave to point out that the State of Rhode Island has already taken an honorable part in gathering information and working out practical methods which are of value not only to the local but to the general development of the fisheries. Through the earlier investigations of your Commission, many questions of importance concerning the life history, breeding habits, means of distribution, and rate of growth of the starfish and the scallop were for the first time settled, and later similar researches on the soft-shell clam were successfully concluded. In addition, a practical method of clam culture was established which formed a basis for an industry which is already started in other states and may ultimately in this state rival in importance the oyster industry.

Eight years ago your Commission, in collaboration with the United States Fish Commission, undertook the problem of rearing lobsters after they had been hatched. The obvious value of this procedure

has appealed to the fisheries authorities in nearly every country and state in whose waters the lobster is found. Attempts to solve the problem have been made in nearly all of these, but have been followed by uniform failure owing to technical difficulties. The experiments at Wickford in 1900 resulted in the fortunate discovery of a new principle which has been since applied with improved devices and apparatus each year until now a method for rearing lobsters is in operation which hatches the eggs and rears the fry to the "lobsterling" stage with such economy and in such numbers that it may be called practical.*

These efforts of your Commission to contribute to the permanent and general development of the fisheries methods as well as to look after the local interests of the fisheries have evoked considerable interest abroad, and inquiries regarding these methods have been received from England, Scotland, the Isle of Man, and the Isle of Jersey; from Spain, France, Germany, Norway, Austria, Ceylon, Japan, and New Zealand. Included in this report is an article on artificial lobster culture by Professor Ehrenbaum of the German Fisheries Station of Helgoland, translated from the official publication of the German Sea Fisheries Association (p. 14). Professor Ehrenbaum's eminent position among fisheries experts, and the fact that he has for many years given especial attention to the question of lobster culture, having written, in 1903, a summary of the work to that date, gives especial interest to his characterization of the Rhode Island method of dealing with the lobster problem.

Particularly gratifying is the confirmation of the opinion often expressed by your Commission, and by others who have studied the habits of the lobster carefully, regarding the relative value of lobsters when first hatched and when reared to the first bottom stage. "It may safely be asserted that the setting free of over 100,000 young lobsters of the first bottom stage—the result of the labors of 1905—lifts the whole work above the plane of experiment; for these thousands have more value for the improvement of the local lobster

* See Ehrenbaum's comment, p. 23.

situation than as many millions of larvæ of the first stage, with the setting free of which we had previously to be satisfied. With the taking up of life on the bottom the great dangers that threaten the life of the young lobster are chiefly over."

During the season of 1907 the output of lobsters in the fourth stage was greater by about 50 per cent. than ever before—294,896 as against 189,384 for the year 1906. The season was unusually late, owing to the cold weather in April and May. The sudden warming of the water at the close of the cold period resulted in crowding the capacity of the plant so that its efficiency was not as great as it might otherwise have been.

In the report of 1906 several suggestions were made for improveing the efficiency of the lobster-rearing plant at Wickford. The weak condition of the eggs when received at the station was a serious handicap. To correct this your Commission recommended the purchase of a launch large enough to fetch the egg lobsters directly from the lower bay at frequent intervals. A satisfactory launch was purchased and was used during the summer for general purposes, but was received too late for lobster operations last season. It is hoped that during the coming season a very great improvement will be made in the condition in which the lobster eggs are received.

A very considerable alteration in the lobster-rearing plant was instituted which will be put into effect next season. The large canvas hatching bags which have been used for several years have been replaced by wooden boxes of the same size. The boxes, like the bags, are provided with windows of woven wire in the bottom and sides, to allow for the circulation of water. Several boxes were tried experimentally last summer and proved to be very satisfactory. They have many advantages over the canvas bags. The latter were easily torn or punctured, especially when they had been in use for more than one season, and even small holes will allow the exit of lobster fry and, worse yet, the entrance of the destructive shrimp and the mummychogs.

Twenty-four hatching boxes each about 10 x 10 x 4 feet, have been

built. They will be placed in the old side floats and in two additional side floats which are to be connected with the original ones. This will about double the capacity of the plant. An additional engine, 3 HP. Morse Fairbanks, which is practically a duplicate of the original one, has been installed. While either engine is capable of running all of the machinery, it was thought advisable to have a duplicate engine to provide for emergencies. An incidental advantage of the boxes over the bags consists of their usefulness in the hatching of the eggs.

The methods of hatching the eggs, like those of rearing the young, have gone through a gradual evolution at the Wickford plant. At first the eggs were brushed off from the female lobster and were placed in the rearing bags and swirled around in the water by the moving propellers; this method very much resembled that in use in many stations where lobster eggs are hatched in jars. Then a simpler and better method was adopted, namely, that of putting the egg-bearing lobsters into shallow crates and placing these crates in the hatching bags. The young lobsters as fast as they were hatched would go out between the slats of the crate into the water of the hatching bag. Subsequently the depth of these crates was increased, and alterations were made in their construction which proved to be an improvement. The present form of rearing boxes does away with a necessity of special crates, for the old egg-bearing lobsters can be placed directly in the rearing boxes, where they crawl around on the bottom, and as fast as the eggs are hatched the fry rise "automatically" into the current and are kept off the bottom by the movement of the revolving paddles. As the lobsters are (like hens) the best possible incubators, and as the large size of the boxes and the excellent circulation of the water allow freedom of movement and comfortable surroundings, the scheme is nearly ideal in simplicity and effectiveness.

Another desideratum which has been mentioned in previous reports is an ideal food for the fry. Among the many foods that have been tried, chopped clams have seemed to give the best results,

but are expensive and to some extent wasteful. A careful series of experiments was conducted last season with various foods, viz., clams, liver, and beef, to determine their relative value as food for the young lobsters from the first stage to a stage considerably later than the fourth. The general results of these experiments indicate that shredded beef is, on the whole, a more suitable food, and less expensive than clams. Besides the lobster work, other operations have been actively conducted by the staff at the Wickford laboratory. Records of the temperature and density of the water; of the places in the Bay where clams have set; of the arrival and departure of fishes; and data regarding the occurrence of the young of various fishes like squeteague, menhaden, tautog, etc., have been collected and placed on file for future reference.

In connection with the improvements in the equipment of the Wickford station it may be mentioned that a houseboat has been built by the member of your Commission in immediate charge of the station, at his own expense. This floating residence is anchored in the vicinity of the laboratory in Mill Cove, Wickford.

Your Commission has employed three deputies to assist in the enforcement of the laws. Two of them have devoted their time exclusively to the enforcement of the lobster law. While it is and always will be impossible to prevent entirely the unlawful taking of short lobsters, the enforcement of the laws at the hands of the Deputy Commissioners has resulted in preventing immense destruction of young lobsters which in a year or two will come to maturity.

Discussion of the legislation in regard to the protection of lobsters has been frequent of late in this and neighboring states, particularly in regard to the proposition which Dr. Field of the Massachusetts Commission of Fish and Game has ably set forth to the effect that the old rather than the young lobsters should be protected by the law.

Your Commission does not accept this view of the case. That large lobsters produce more eggs than small ones, no one can, of course, deny, but it must not be forgotten that for the increase of the

individuals of the species, protection of the eggs and young is quite as effective as great productivity. The crawfish, which produces perhaps one hundred fry and protects them, maintained its numbers as well as the lobster which produces two hundred times as many and does not protect them. The dogfish, which produces not more than eight or ten young in a season, but protects these until they are nearly a foot long, has a reproductive power, or "germ fertility," equal to that of many species of fishes which produce a thousand times more fry and leave them unprotected. Examples of this simple biological fact could be multiplied by the hundred and extended through all classes of marine animals. The number of eggs is not an index of the abundance of a species, and a few individuals which by means of natural or artificial protection or by sheer good luck have got past the exceedingly critical early stages are often worth myriads of free-swimming larvae. It would seem, then, that energy could be more effectually expended in protecting the fry and the partially grown young than in increasing the number of eggs. Another fact which militates against the proposition in question is that in proportion as the large lobsters are excluded from the market the demand for young lobsters must increase.

The following paper, already referred to in this report, by Professor Ehrenbaum of the German Fisheries Association, is introduced as giving an interesting and impartial statement of the lobster-culture problem from the point of view of an outsider. The last part of the paper, dealing with the rate of growth of the lobster, is omitted, as are also the figures and their description.

# ARTIFICIAL CULTURE AND GROWTH OF THE LOBSTER.*

BY PROFESSOR EHRENBAUM, HELGOLAND.

Since I reported in No. 5 of the volume for 1903 of these "Mitteilungen" in regard to recent, especially the Norwegian, researches (by A. Appellöf) on the lobster, the question of satisfactory procedure in the artificial rearing of lobsters has been worked at pretty actively, and—as must be added—not without success. Apropos of a report on fisheries at the World's Fair in St. Louis ("Mitteilungen" vol. for 1905, p. 259–294), I have already pointed out what a lively interest the American Fish Commission especially has shown in recent years in lobster culture and with what remarkable success their efforts have been crowned.

To-day the problem can be looked upon as practically solved, and, since it has gone so far in the United States that after many and varied experiments a system has been worked out which can be operated practically, it therefore appears timely to give to a wider circle of persons interested a view into the condition of things and to set forth the prospects that open up for the future.

For better understanding, let us here again call attention briefly to some important points in the life history of the lobster, and at the same time point out the difficulties that lie in the problem of artificial lobster culture.

While artificial fish culture starts always with the fertilization of sexual products ripe for deposition, the conditions in the case of the lobster are decidedly different. The fertilization of the mature eggs, which probably follows immediately after their extrusion from the

*Translated from the "Mitteilungen des Deutschen Seefischerei-Vereins" vol. 23, No. 6, June 1907, p. 178–189.

body of the female, goes on under all circumstances without the help of man, and moreover during the first months of embryonic development there is no avail in any artificial interference for the purpose of hastening or even of merely continuing the development. The embryonic development of the lobster has the enormously long duration of 11 to 12 months, and no hatchery is able to work with such precision that the eggs entrusted to it shall remain normal for almost a year. Also, an artificial hatching lasting so long would occasion such heavy expenses that they would stand out of proportion to the attainable result. Therefore it is out of the question that the fertilized lobster eggs should go through their entire development under artificial conditions. Again, for such a long time artificial means would hardly be able to reproduce the favorable conditions under which the eggs normally develop on the swimming appendages on the under side of the female lobster.

But when in spring, after the long pause of winter, lobster catching begins, and by and by pregnant females are taken in the traps—at the beginning of the fishing season this happens not at all, or very rarely—the embryos which these females carry on their bodies are then already three-fourths of a year old and more, and stand at a longer or shorter interval before hatching out. Now, in order not to lose these pregnant females in commerce and consumption, and, on the other hand, not to destroy a numerous and already well-developed progeny, devices have been tried for stripping off the mature eggs carefully from the mother and for bringing them to complete maturity and hatching them in specially constructed apparatus, while the mothers themselves are delivered over to consumption.

This device readily showed itself completely practical to this extent, that, when properly placed in hatching apparatus or floating boxes, the eggs developed very well and with relatively little loss up to hatching out, so that we were in a position to give back to the sea, in the shape of young lobsters, what we had robbed it of in the shape of maturing embryos together with their mothers.

The commission of inspection for the Newfoundland lobster

fishery, which is one of the largest in the world, has worked for years on this program, and, since the beginning of its activity, has set free in the bays of the island hundreds of millions of new-born lobster larvæ after they have come out of the eggs hatched in floating boxes. The eggs themselves were stripped off from the pregnant females, and the fish inspectors keep close watch, that in the great canning factories no pregnant female is used before its eggs have been stripped off.

But it must not be overlooked that no matter how carefully the work is done, the larvæ being set free as near as possible to the bottom, nevertheless bunching the young larvæ in a limited area is unavoidable, which under natural conditions never happens. This immediately attracts enemies and causes a speedy end of the young lobsters. In nature care is taken that not even the offspring of one female come into the water all at once, since the larvae usually hatch out a few at a time and mostly in the night.

The circumstance that in nature the many millions of new-born larvæ scatter themselves over a vast surface, and that therefore the magnitude of the dangers threatening life is greatly reduced, gives natural conditions an extraordinary advantage over the conditions supplied by artificial breeding. The value and significance of this can not be overestimated.

Yet we could well be satisfied with the achievements of artificial lobster culture if it were indeed allowable—as many believe—to measure the value of artificial breeding by the number of new-born larvæ put into the water. But this assumption must be firmly opposed.

Certainly it is of value if numerous germs, which the intensive fish trade would heedlessly destroy, remain through artificial means more or less completely kept in the sea, for thereby in the most favorable case the injurious influence of fishing is approximately counteracted.

But artificial breeding ought not to be content to do at its best only what nature does unaided. It obtains its real justification only when it is in a position to surpass nature in her achievements. Only thus

can it accomplish the task set it—to fill up the gaps caused by years of excessive fishing.

In the particular case of the lobster about 30,000 new-born larvæ, which represent the average total mass of the brood produced by one pair of lobsters during their lifetime, contain the potentiality of only one pair of mature lobsters. For if under natural conditions, from these 30,000 new-born larvæ there are, after a lapse of 7 to 9 years, more than one pair actually living, there would arise an over-population of the sea, as regards lobsters. The existing equilibrium in the economy of nature demands this heavy mortality or life-risk among the growing lobsters; or, to speak more correctly, on account of the numerous dangers that encompass the growing lobster in his particular mode of life, the creature must be endowed by nature with a germ-fertility that shall suffice, in spite of the great decimation which the struggle for existence entails, to guarantee, nevertheless, the requisite posterity.

We have simply to regard the germ-fertility of an animal, i. e., the mass of germs which the species in question brings to maturity, as an expression for the sum of the dangers which threaten the animal during its development up to sexual maturity and the consequent propagation.

In the case of the oyster, which has a germ-fertility of over a million, and of the cod, which brings even three to nine million eggs to maturity, their dangers must be materially greater than in the case of the lobster, which is satisfied with a production of 20,000 eggs on an average at each laying; and again, the lobster's dangers must be greater than those of the crawfish, which brings only 60 to 120 eggs to maturity.

Now if artificial breeding aims to surpass the achievements of nature, and bring a greater number of larvæ or new-born to development and full growth than nature is able to do, it is necessary first of all to reduce the number and magnitude of the dangers and to protect the growing animal, particularly in that period when its life is especially threatened.

If with this purpose one approaches the plan of an artificial lobster culture, there can no longer be any doubt at what point the protective measures of the lobster culturist must be applied.

The lobster during its embryonic development, although this lasts very long, enjoys remarkable protection on the part of the mother animal, and also later, if the young lobster once gets developed so far that it can live on the bottom—which happens usually in the third week of its life—it is able in a remarkable manner to protect itself from all kinds of enemies, so that its life is threatened in a relatively small degree.

But in the first two to three weeks of its life, when the lobster moves about in the upper layers of the water, more tumbling about than swimming, and leads a plankton life, the number of the dangers that threaten its life are so much the greater. Its slow movements, its unusually vivid coloring, and its size work together to the result that despite the greatest care it falls a victim to numerous robbers, especially among the fishes, so that this short section in the life of the lobster may rightfully be called its critical period.

From this state of things, it is very clear that here must lie the point of attack for artificial breeding; it must try to bring the young lobster over the short period of its plankton life and keep it under protective care until it, as a normal dweller on the bottom, shall find the necessary protection in natural conditions.

Since there is here only the question of the brief period of two to three weeks, one can hardly imagine a more ideal subject for artificial breeding than the lobster, for it looks as if, with comparatively small means and in a short time, a grand triumph could be wrested from nature through artificial interference.

So it looks!

But as a matter of fact there are very great difficulties to overcome.

The first attempts to raise new-born lobsters in captivity, to bring them past the first moultings and to lead them over into the fourth life-stage, in which life on the bottom can be taken up, ended in a complete fiasco. A fatal inclination of the larvæ toward cannibal-

ism, which is not to be lessened by a plentiful supply of food, as well as the perishing of numerous specimens in moulting, have been the principal impediments to the success of the culture experiments which were carried on with the same zeal in the United States as in Europe—here especially in Norway.

The Norwegian investigator, Appellöf, who has many times reported his experiments in the "Aarsberetninger der Selskab for de norske Fiskeriers Fremme," tells us that the first two moultings (to the first and second life-stage) usually went smoothly, while the two following demanded an enormous sacrifice. With the exercise of the greatest care he succeeded in one case in bringing over, out of a large number of larvæ, 1,500 into the second stage, and from them 400 into the third stage, and finally 100 into the fourth stage.

It seemed as if the difficulties present were insurmountable, and that after all it would be the most profitable to put into the open water, with the least possible losses, the artificially hatched lobster larvæ directly after hatching out.

But in spite of all failures, the breeding experiments were continued most zealously, especially by the Americans; and from that quarter the announcement was made to the world, a few year's ago, that the continued efforts had at last been successful in finding a practical way for the raising of young lobsters. Already in my report, mentioned at the beginning, on the Fishery Exhibit in St. Louis ("Mitteilungen," volume for 1905, p. 278), I brought out what grave doubts these reports on the results of breeding by Americans had met at the outset, especially among all those who, like myself, had become convinced of the difficulties in the case. But now, since I have seen, at the floating station of the Rhode Island Commissioners of Inland Fisheries, at Wickford, near Providence, Rhode Island, the palpable proofs, can I no longer exclude the conviction that the perseverance and ingenuity of the director of the station has succeeded in solving the difficult problem of lobster culture.

The credit for this belongs to Dr. A. D. Mead, a professor in the Anatomical Department of Brown University in Providence, R. I.,

who has reported repeatedly and *in extenso* in the not easily accessible Annual Reports of the Commissioners of Inland Fisheries of Rhode Island (29th to 35th report), and also recently in a short summary in the Proceedings of the American Fisheries Society, 1905 (p. 156–166).

From the latter treatise we learn that the undertaking of the experiments on the part of the Rhode Island Fish Commission—partly in collaboration with the U. S. Fisheries Bureau—is owing to the instigation of Dr. H. C. Bumpus, who was formerly himself engaged in studies on the lobster, and who was at that time Director of the Wood's Hole Laboratory of the U. S. Fish Commission and a member of the Rhode Island Fish Commission, and who now is Director of the great Museum of Natural History in New York. The experiments began in the year 1900 with gauze bags, which were hung in the water and allowed the water free access into their interior. But, since the bags were weighted, in calm weather the lobster larvæ gathered, along with remnants of food, in the pockets which were formed by the weights. This was as unfavorable for them as the blowing of the bags out of the water in a strong wind when the weights were removed.

But finally the continuation and variation of the experiments led to the discovery that the secret of success in the culture lies in keeping up a constant motion of the water in the breeding bags. Through this motion of the water a two fold result is obtained: the larvæ are prevented from lodging in corners and folds of the breeding bags and there mutually feasting on one another; and the food is kept evenly suspended in the bag so that it is easily within the reach of all the animals under experiment.

Next it was established by means of a preliminary experiment what advantages the motion of the water afforded. In this case it was carried on by hand with an oar. It became at once apparent that a vastly greater number of larvæ could be carried over into the fourth life-stage than in the earlier experiments, and that these lar-

væ, through the absence of fungal growths and parasites, were much healthier and sturdier than was formerly the case.

In the year 1901 a mechanical device was employed for the first time to keep up the motion of the water, and in connection with it an enlarged and improved form was given to the whole hatchery, and this essentially has been retained.

The arrangement of the hatchery, housed on a large float can easily be seen from the illustrations.* In the midst is a so-called "houseboat," with two superstructures, a laboratory and a tool room in which is a small, 2½ HP gasoline motor. The middle portion carries two small hatching bags, 6 by 6 feet on the bottom and 4 feet deep. On each side, connected with the middle portion is a float built of 6-inch beams and kept up by barrels. In the spaces between these beams are in each case five large hatching bags, 12 by 12 feet on the bottom and 4 feet deep.

The hatching bags consist of sail-cloth and have in the bottom a large window filled with wide-mesh gauze, which allows the water free entrance. They are fastened to sliding poles, on which they can be lowered or raised at will.

While the machine is running the upper rims of the bags are above the water. To the shafting on the float are attached a number of two-bladed propellers, so that one is in the middle of every hatching bag and by its turning keeps the water within the hatching bag in constant motion. The motion is very slow and gauged to about ten revolutions a minute. The action can be regulated by adjustment of the propellor blades on the axle. It produces an upward whirl in the water strong enough to keep constantly in suspension the larvæ and the finely divided food. The vertical axle of each propeller is connected to horizontal shafts by means of gears. The horizontal shafts on their part are carried often long distances, by means of repeated couplings, to the motor. The connection of the shafting of the great side floats with the main shaft on the middle pontoon requires a kind of balljoint and a very flex-

[* Illustrations showing the arrangement of the hatchery can be found in previous reports, especially in the report for 1905.]

ible one. For it is obvious that the separate parts of the great hatchery are exposed on the water to rather large and irregular motions, although the relatively calm water of the protected Wickford Harbor was chosen for the anchorage.

This apparatus is utilized at the same time for the hatching of the eggs and for the raising of the larvæ, and has proved itself equally good for both purposes.

While in former years the number of the lobsters in the fourth stage was not above 100, already in the year 1900, when the mechanical stirring of the water—at first by hand—was introduced in Wickford, 3,425 lobsters of the fourth stage were obtained; but in the following years, by the help of the above described mechanical outfit, the number of lobsters in the fourth stage was:

| | |
|---|---|
| 1901 | 8,974 |
| 1902 | 27,300 |
| 1903 | 13,500 |
| 1904 | 50,597 |
| 1905 | 102,000* |

It should be mentioned that these figures are not the result of an estimate, but that the larvæ were counted singly after being taken out of the hatching bags with a tea strainer.

In order to pass a judgment giving due credit to the work of the hatchery, one must know not only the number of the lobsters of the fourth stage which are finally set free in open water, but also the number of those hatched out, with which the rearing experiments were made. But since these hatch out in the same hatching bags in which they are afterwards reared; only in a few cases could an account be kept of the relation which the number of the lobsters of the fourth stage held to that of the first stage.

The following cases are reported by Dr. Mead:

On June 7th and 8th, 1905, 20,000 new-born lobsters were counted out into a hatching bag. The fourth or bottom-stage began to

[* 1905, 103,572; 1906, 190,000, fourth stage, 25,000, fifth stage; 1907, 294,896.]

appear in ten to twelve days, and a total of 9,635 individuals, or 48 per cent. of young lobsters of the earliest bottom-stage, were counted out.

On June 28th and 29th, 1905, from a like experiment with 20,000 of the first stage, 8,178, that is, 40.8 per cent., were obtained.

Since no special care was taken in these two experiments, they can be regarded as typical. Already earlier, with a smaller experiment number, higher figures had been obtained; e. g., in 1901, from 1,000 new-born, 500 of the fourth stage, that is, 50 per cent.

At any rate it can be regarded as settled that at no experiment made earlier and elsewhere has any approach to this result been attained, and that the methods adopted by Dr. Mead must be a pattern for all further attempts that shall be made in this field. It may safely be asserted that the setting free of over 100,000 young lobsters of the first bottom-stage—the result of the labors of 1905—lifts the whole work above the plane of experiment; for these thousands have more value for the improvement of the local lobster situation than as many millions of larvæ of the first stage, with the setting free of which we had previously to be satisfied. With the taking up of life on the bottom the great dangers that threaten the life of the young lobster are chiefly over.

Whether the setting free of these lobsters has exerted a perceptible influence upon conditions on the shores of Rhode Island, appears somewhat questionable. I should hesitate to raise the question at all had not such a conscientious and discriminating investigator as Dr. Mead felt called upon to state that the fishermen had reported the appearance of a great number of small lobsters which the traps would not yet hold, but which slipped out when the traps were raised. The possibility of a connection between these small lobsters and those set free in recent years can not be denied.

If one looks back upon the peculiarities of the American method of lobster hatching, everything seems so simple and self-evident that the question arises why this path was not travelled before. On the other hand the very simplicity of execution makes the affair

very credible and recalls the egg of Columbus. Besides it should be remarked that the idea of employing mechanically stirred water in an aquarium for artificial rearing has often, in recent times, been turned to account. So, e. g., the "plunger jar" of C. T. Brown, first used in England for raising *medusæ* and other delicate organisms, in which the motion of the water is produced by the raising and lowering of a glass plate in the experiment jar, is constructed on a similar idea (cf. Journ. Marine Biol. Assoc. Plymouth V, 1897–99, p. 176, fig. 1;) and the apparatus of the Frenchman, Fabre Domergue and E. Biétrix employed with great success in the raising of flatfish larvæ, especially soles (of. Développement de la Sole, Paris, 1905, Vuibert et Nony, Editeurs, p. 219 et seq., fig. 37–39) is really nothing else than a—clearly independently constructed— repetition of the Mead lobster-hatching apparatus on a small scale and for laboratory purposes, in which the gasoline machine is replaced by a ¼ HP hot air motor and the large hatching bags of canvas by glass dishes containing 12 liters, while in place of the propeller with its two blades an upright, rotating glass plate is used with an inclination toward the vertical axis of rotation.*

These similarly directed efforts to find the proper ways and means for the construction of apparatus for the artificial rearing of delicate developmental marine forms strengthen the impression that the right way has been entered upon, and the success already attained make it a certainty that the possible improvement yet to be made can concern only accessories. To the last belongs the not yet satisfactorily settled question concerning the proper food for the young lobster larvæ. Thus far finely minced clams, and shredded fish have been employed but without establishing the conviction that this is the correct food. Also better means must be found for keeping off disturbing plant growths, especially diatoms, which are only moderately kept down by shading the hatching bags. The keeping up of a proper temperature, not too low, as

* An apparatus of this kind is now employed in Helgoland for experiments in lobster raising.

well as pure, well aërated and circulating water and proper food, contribute to develop the new-born larvæ farther and to bring them in the shortest possible time to the bottom stage.

For us an outlook so satisfactory on the practicability of artificial lobster culture must naturally involve the question whether and how far the approved new method of culture is applicable to our local conditions at home.

The answer must unfortunately be in the negative.

The roadsteads of the island of Helgoland are far too unprotected and rough to permit breeding experiments to be ventured at all upon anchored floats. In America they were carried on, as has already been said, in an entirely protected bay with calm water. It admits of no doubt that like favorable conditions may be found on the British coast as well as in the fiords of Norway, and perhaps also on the Austrian coast of the Adriatic, where also there is great complaint of the diminishing of the lobster supply. In Helgoland, as far as we can now see ahead, the lobster-culture experiments must always be confined to the small scale of the laboratory, which at any rate permits the demonstration to visitors to the Helgoland exhibition aquarium the hatching and culture of the lobster and afford the opportunity, not to be undervalued, for observation on the moulting and growth of the lobster, but which never will attain practical significance for maintaining or increasing the Helgoland lobster supply.

If now, on the one hand, we at Helgoland lack the possibility of carrying on practical lobster raising, yet, on the other hand, it is satisfactory to know that there exist no serious indications of endangering the Helgoland lobster supply through fishing, so that there has not yet arisen a grave need of recourse to the aid of artificial culture.

The fishery is carried on in a very rational manner, and the observance of a three months closed season in summer, a minimum size fixed by law, and last, not least, also the peculiar life-conditions of the lobster, which afford it a very strong protection, have

thus far sufficed to give the catch of the Helgoland lobster fishery a satisfactory uniformity. There are also grounds for believing that the Helgoland production in the future as well as in the past will satisfy the demands of consumption, and in addition it is gratifying that the general rise in prices, which the Helgoland lobsters have also shared, has been reduced in a gratifying manner since the abolition of the import duty, granted in the summer of 1906.

The following is the financial statement for the year 1907:

*State of Rhode Island in account with Commissioners of Inland Fisheries.*

| | | | |
|---|---|---|---|
| 1907. | | Dr. | |
| Oct. | 1. | To paid American Fish Culture Co., for 40,000 trout and distribution of same | $1,053 16 |
| Dec. | 31. | To expenses of Commissioners | 570 13 |
| | | To laboratory | 3,859 96 |
| | | To egg lobsters | 1,960 60 |
| | | To new launch | 2,203 80 |
| | | To new engine for laboratory | 169 03 |
| | | To deputies under lobster law | 2,300 25 |
| | | | $12,116 93 |
| 1907. | | Cr. | |
| Feb. | 20. | By received from State Treasurer | $1 00 |
| | 14. | " " " " | 11 25 |
| | | " " " " | 40 51 |
| April | 1. | " " " " | 1 50 |
| | | " " " " | 83 45 |
| | | " " " " | 68 85 |
| | 18. | " " " " | 61 60 |
| | | " " " " | 64 25 |
| | | " " " " | 75 25 |
| | | " " " " | 82 05 |
| | | " " " " | 30 00 |
| | | " " " " | 210 00 |
| | | " " " " | 12 07 |
| | | " " " " | 19 06 |
| | | " " " " | 17 25 |

| | | | |
|---|---|---|---|
| April | 18. | By received from State Treasurer | $5 70 |
| | 28. | " " " " | 79 20 |
| | | " " " " | 69 80 |
| | | " " " " | 25 00 |
| May | 1. | " " " " | 60 92 |
| | | " " " " | 12 00 |
| | | " " " " | 19 50 |
| | 3. | " " " " | 1 71 |
| | | " " " " | 21 09 |
| | | " " " " | 22 10 |
| | | " " " " | 5 49 |
| | | " " " " | 30 00 |
| | | " " " " | 25 00 |
| | | " " " " | 25 75 |
| | | " " " " | 23 00 |
| | 8. | " " " " | 8 20 |
| | 15. | " " " " | 4 00 |
| | 17. | " " " " | 66 21 |
| | | " " " " | 20 00 |
| | | " " " " | 18 00 |
| | 22. | " " " " | 11 00 |
| | 24. | " " " " | 12 48 |
| | 29. | " " " " | 18 66 |
| | | " " " " | 70 10 |
| | | " " " " | 78 83 |
| | | " " " " | 150 00 |
| | | " " " " | 24 94 |
| | | " " " " | 20 00 |
| | | " " " " | 90 95 |
| | | " " " " | 79 00 |
| | | " " " " | 2 15 |
| | | " " " " | 3 00 |
| | 31. | " " " " | 35 00 |
| | | " " " " | 20 00 |
| | | " " " " | 21 00 |
| | | " " " " | 13 25 |
| June | 5. | " " " " | 24 10 |
| | | " " " " | 22 69 |
| | | " " " " | 29 20 |
| | 13. | " " " " | 6 85 |

| | | | |
|---|---|---|---|
| June | 14. | By received from State Treasurer | $70 39 |
| | | " " " " | 26 00 |
| | | " " " " | 17 25 |
| | | " " " " | 30 95 |
| | 21. | " " " " | 2,100 00 |
| | 26. | " " " " | 90 20 |
| | | " " " " | 81 55 |
| | | " " " " | 1 50 |
| | 28. | " " " " | 42 10 |
| | | " " " " | 139 63 |
| | | " " " " | 25 00 |
| | | " " " " | 15 00 |
| | | " " " " | 27 85 |
| | | " " " " | 15 75 |
| | | " " " " | 26 00 |
| | | " " " " | 45 00 |
| July | 3. | " " " " | 2 00 |
| | 12. | " " " " | 100 20 |
| | | " " " " | 14 00 |
| | | " " " " | 18 67 |
| | | " " " " | 22 00 |
| | | " " " " | 21 10 |
| | | " " " " | 25 50 |
| | | " " " " | 22 95 |
| | | " " " " | 17 60 |
| | 19. | " " " " | 33 00 |
| | | " " " " | 69 62 |
| | 31. | " " " " | 90 10 |
| | | " " " " | 82 45 |
| | | " " " " | 15 00 |
| | | " " " " | 6 35 |
| | | " " " " | 61 45 |
| | | " " " " | 51 00 |
| | | " " " " | 58 70 |
| Aug. | 1. | " " " " | 3 76 |
| | | " " " " | 8 07 |
| | | " " " " | 21 31 |
| | | " " " " | 3 89 |
| | | " " " " | 7 50 |
| | | " " " " | 30 00 |

| | | | |
|---|---|---|---|
| Aug. | 1. | By received from State Treasurer | $18 00 |
| | | " " " " | 24 40 |
| | | " " " " | 13 34 |
| | | " " " " | 82 67 |
| | | " " " " | 10 31 |
| | | " " " " | 5 06 |
| | | " " " " | 5 90 |
| | | " " " " | 2 00 |
| | | " " " " | 2 00 |
| | | " " " " | 82 56 |
| | | " " " " | 8 20 |
| | | " " " " | 20 42 |
| | | " " " " | 43 49 |
| | | " " " " | 13 50 |
| | | " " " " | 185 95 |
| | | " " " " | 25 42 |
| | | " " " " | 10 90 |
| | 7. | " " " " | 23 60 |
| | | " " " " | 22 10 |
| | | " " " " | 22 80 |
| | | " " " " | 20 00 |
| | | " " " " | 20 00 |
| | | " " " " | 48 00 |
| | | " " " " | 22 00 |
| | | " " " " | 19 55 |
| | | " " " " | 35 00 |
| | | " " " " | 20 32 |
| | | " " " " | 8 00 |
| | | " " " " | 152 72 |
| | | " " " " | 169 03 |
| | 13. | " " " " | 46 50 |
| | 21. | " " " " | 35 00 |
| | | " " " " | 20 00 |
| | | " " " " | 25 00 |
| | | " " " " | 20 00 |
| | | " " " " | 15 00 |
| | 28. | " " " " | 94 85 |
| | | " " " " | 82 60 |
| | 30. | " " " " | 19 98 |
| | | " " " " | 35 00 |

| | | | |
|---|---|---|---|
| Aug. | 30. | By received from State Treasurer | $20 00 |
| | | " " " " | 21 85 |
| | | " " " " | 19 00 |
| | | " " " " | 6 75 |
| | | " " " " | 1,359 78 |
| | | " " " " | 503 35 |
| | | " " " " | 25 50 |
| | | " " " " | 7 00 |
| Sept. | 4. | " " " " | 58 80 |
| | | " " " " | 65 10 |
| | 20. | " " " " | 95 83 |
| | 25. | " " " " | 2 55 |
| | | " " " " | 89 05 |
| | | " " " " | 20 00 |
| | | " " " " | 97 47 |
| | | " " " " | 1 00 |
| | 27. | " " " " | 90 30 |
| | | " " " " | 80 90 |
| | 30. | " " " " | 56 30 |
| | | " " " " | 106 52 |
| Oct. | 2. | " " " " | 35 00 |
| | | " " " " | 20 00 |
| | | " " " " | 17 29 |
| | | " " " " | 40 00 |
| | | " " " " | 1,000 00 |
| | 4. | " " " " | 1 50 |
| | | " " " " | 3 10 |
| | 11. | " " " " | 35 00 |
| | | " " " " | 10 00 |
| | 23. | " " " " | 2 27 |
| | 30. | " " " " | 92 30 |
| | | " " " " | 77 90 |
| | | " " " " | 35 00 |
| Nov. | 1. | " " " " | 24 10 |
| | 6. | " " " " | 37 20 |
| | | " " " " | 10 75 |
| | | " " " " | 20 00 |
| | 13. | " " " " | 40 |
| | | " " " " | 35 00 |
| | 27. | " " " " | 91 10 |

| | | |
|---|---|---|
| Nov. 27. | By received from State Treasurer | $35 00 |
| | " " " " | 20 88 |
| | " " " " | 87 75 |
| | " " " " | 21 00 |
| | " " " " | 19 30 |
| | " " " " | 13 69 |
| Dec. 4. | " " " " | 28 20 |
| | " " " " | 25 20 |
| | " " " " | 3 50 |
| 6. | " " " " | 20 00 |
| 12. | " " " " | 48 56 |
| | " " " " | 5 20 |
| 18. | " " " " | 52 30 |
| | " " " " | 2 50 |
| | " " " " | 45 10 |
| | " " " " | 84 30 |
| | " " " " | 73 10 |
| | | $12,116 93 |

Respectfully submitted,

RHODE ISLAND COMMISSIONERS OF INLAND FISHERIES.

HENRY T. ROOT, *President,*

December 31, 1907. *Treasurer and Auditor.*

## The Stocking of Ponds and Streams with Fresh-Water Fishes.

### *Trout.*

The Commission has purchased of the American Fish Culture Company, of Carolina, R. I., 40,000 yearling trout. These have been distributed in the various streams of the State. We wish to take this opportunity to acknowledge the assistance rendered by many of the fishermen in the work of distribution.

### *Shad.*

For a few years past the United States Bureau of Fisheries has been unable to supply your Commission with shad fry, because of the scarcity of the spawn.

## The Collection of Data and Statistics Relating to the Commerial Fisheries.

The difficulty of collecting complete and accurate statistics of the total catch of fishes has been remarked upon in previous reports. There are so many and so various channels through which fishes reach the market or the private consumer that it is practically impossible to keep track of them all. This difficulty is not peculiar to Rhode Island, but applies to the fishing industry generally. Nevertheless, a fair indication of the relative status of the fisheries is to be had by comparing the statistics taken year after year from the same sources. With this word of explanation, the following tables of the catch of fishes and lobsters, based upon the records of dealers and transportation lines, are, as heretofore, submitted:

*Table Showing the Amount of Fish, Lobsters, and Other Sea Products Shipped Monthly from Newport by the Principal Transportation Companies During the Year* 1907.

| | Barrels Fish. | Barrels Lobsters. | Barrels Crabs. | Barrels Clams. | Barrels Sounds. | No. Sword-fish. | No. Sturgeons. | No. Horse-mackerel. | Barrels Oysters. | No. Sharks. | No. Turtles. | Barrels Spawn. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 1,131 | 247 | ... | ... | ... | ... | ... | ... | 3 | ... | ... | ... |
| February | 371 | 144 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| March | 638 | 83 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| April | 959 | 168 | ... | 2 | ... | ... | ... | ... | 2 | ... | ... | ... |
| May | 10,303 | 159 | 8 | 1 | ... | ... | 2 | ... | ... | ... | ... | ... |
| June | 20,350 | 214 | 76 | 1 | 1 | 17 | 4 | 17 | ... | ... | ... | ... |
| July | 9 340 | 195 | 134 | 6 | 5 | 118 | 3 | 67 | ... | 2 | 1 | ... |
| August | 6,415 | 185 | 70 | ... | 5 | 116 | ... | 14 | 3 | 5 | ... | 8 |
| September | 3,837 | 121 | 20 | ... | 4 | 12 | 1 | 6 | ... | 3 | ... | ... |
| October | 3,124 | 11 | 11 | 2 | 4 | ... | ... | 9 | 10 | 2 | ... | ... |
| November | 1,928 | ..... | 2 | ... | 5 | ... | 3 | ... | ... | ... | ... | ... |
| December | 1,278 | 2 | 1 | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Total | 59,674 | 1,529 | 322 | 12 | 24 | 263 | 13 | 112 | 18 | 12 | 1 | 8 |

*Table Showing Shipment of Fish, Lobsters and Other Sea Products from Newport for the Last Twenty-one Years.*

| | Barrels Fish. | Barrels Lobsters. | Barrels Quahaugs. | Barrels Crabs. | Barrels Clams. | Barrels Spawn. | Barrels Sounds. | Number Sword-fish. | Number Sturgeon. | Number Horse-mackerel. | Number Turtles. | Number Sharks. | Number Porpoise. | Barrels Eels. | Barrels Oysters. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1887 | 16,657 | 834 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 1888 | 15,033 | 1,161 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 1889 | 19,306 | 2 047 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 1890 | 8,933 | 2,650 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 1891 | 18.032 | 2,204 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 1892 | 26,832 | 2,123 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 1893 | 24,452 | 1,399 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 1894 | 17,769 | 2,392 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 1895 | 24,622 | 2,119 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 1896 | 20,425 | 1,728 | ... | ... | ... | ... | ... | 143 | ... | ... | ... | ... | ... | ... | ... |
| 1897 | 52,098 | 2,039 | ... | ... | ... | ... | ... | 45 | ... | ... | ... | ... | ... | ... | ... |
| 1898 | 34,065 | 1,163 | ... | ... | ... | ... | ... | 74 | ... | ... | ... | ... | ... | ... | ... |
| 1899 | 34,917 | 4,143 | ... | ... | ... | ... | ... | 162 | ... | ... | ... | ... | ... | ... | ... |
| 1900 | 38,184 | 4,793 | ... | ... | ... | ... | ... | 166 | ... | ... | ... | ... | ... | ... | ... |
| 1901 | 50,500 | 4,393 | ... | ... | ... | ... | ... | 21 | ... | ... | ... | ... | ... | ... | ... |
| 1902 | 53,986 | 4.342 | ... | 1 | ... | ... | ... | 179 | ... | ... | ... | ... | ... | ... | ... |
| 1903 | 54,384 | 1,474 | ... | 84 | ... | ... | ... | 164 | 11 | 79 | ... | ... | ... | 18 | ... |
| 1904 | 62,106 | 1,921 | ... | 45 | 8 | ... | 0.. | 554 | ... | 336 | ... | ... | ... | ... | ... |
| 1905 | 50,127 | 977 | ... | 122 | 80 | 3 | 23 | 723 | 26 | 91 | ... | 1 | 1 | ... | ... |
| 1906 | 60,855 | 1,306½ | 233 | 17 | 15 | 2 | 6 | 811 | 11 | 40 | 2 | 12 | 1 | ... | 112 |
| 1907 | 59,674 | 1,529 | ... | 322 | 12 | 8 | 24 | 263 | 13 | 112 | 1 | 12 | ... | ... | 18 |
| Total | 715,957 | 46,737½ | 233 | 891 | 115 | 13 | 53 | 3305 | 61 | 658 | 3 | 25 | 2 | 18 | 130 |

*The Number of Pounds of Lobster Caught in Rhode Island Waters for the Season of* 1907, *Compared with* 1904, 1905, 1906.

Compiled by Wm. T. Luth and James Harrington, Deputy Commissioners.

| Fish Markets. | 1904. | 1905. | 1906. | 1907. |
|---|---|---|---|---|
| H. McGinn | 113,420 | 147,464 | 182,462 | 209,204 |
| C. B. Anderson | 34,074 | 31,965 | 63,398 | 158,427 |
| Alex Raftakes | ...... | ...... | ...... | 71,876 |
| J. W. Hammond | ...... | ...... | ...... | 33,568 |
| Saloons and Restaurants | 6,700 | 45,436 | 41,850 | 37,814 |
| Burlingame & Carry | 12,000 | 8,079 | 6,480 | 6,300 |
| Tollefsen & Dewitt | 10,000 | 15,000 | 15,000 | 16,000 |
| C. Ash | 15,000 | 20,636 | 11,500 | 19,200 |
| Wyatt | 9,000 | 8,004 | 7,548 | 7,000 |
| E. C. Smith | 9,500 | 10,000 | 10,135 | 6,000 |
| Easterbrooks | 5,000 | 6,525 | 6,550 | 6,500 |
| Lancaster | 5,000 | ...... | ...... | ...... |
| F. Lawton | 6,000 | 8,000 | 8,000 | 8,000 |
| J. Ring | 800 | 550 | 550 | ...... |
| Crowly | 500 | ...... | ...... | ...... |
| Brightman | ...... | ...... | ...... | 1,800 |
| | 226,994 | 301,659 | 353,573 | 581,189 |
| Capt. J. A. Pettey, Sakonnet | | 97,641 | 163,341 | 193,243 |
| Block Island, Watch Hill, Narragansett Pier, | 150,000 | 100,000 | 155,000 | 155,000 |
| Total | 376,994 | 499,300 | 671,914 | 929,432 |

*The Number of Boats Engaged in Lobster Fishing in this State for the Season of* 1907.

Compiled by Wm. T. Luth and James Harrington, Deputy Commissioners.

| | Sail and power boats. | Row boats | Pots. | Men. |
|---|---|---|---|---|
| Newport | 44 | 42 | 7,507 | 116 |
| Narragansett Pier | 4 | 5 | 365 | 7 |
| Saunderstown | 2 | 1 | 225 | 5 |
| Wickford | 1 | 3 | 125 | 5 |
| Sakonnet | 2 | 5 | 350 | 7 |
| East River | 4 | 6 | 375 | 11 |
| Warren and Bristol | 2 | 2 | 200 | 5 |
| Green Hill | .. | 1 | 70 | 1 |
| Watch Hill | 5 | 2 | 475 | 10 |
| Block Island | 11 | 2 | 1,475 | 22 |
| Jamestown | 5 | 4 | 697 | 14 |
| Point Judith | 2 | 2 | 240 | 6 |
| | 82 | 75 | 12,104 | 209 |

*Lobsters Received from Nova Scotia from December* 20, 1906 *to June* 30, 1907.

Compiled by Wm. T. Luth and James Harrington, Deputy Commissioners.

| | Crates. | Lbs. | Number of short lobsters. | Number of egg lobsters. |
|---|---|---|---|---|
| December, 1906 | 232 | 40,600 | 148 | .. |
| January, 1907 | 931 | 162,925 | 954 | 19 |
| February, 1907 | 270 | 47,250 | 2,476 | 3 |
| March, 1907 | 248 | 43,400 | 360 | .. |
| April, 1907 | 489 | 84,375 | 542 | .. |
| May, 1907 | 144 | 25,200 | 32 | .. |
| June, 1907 | 11 | 1,925 | .. | .. |
| | 2,325 | 405,675 | 4,506 | 22 |

The following table shows the amount of lobsters shipped by boat to Providence during the season from April 15 to October 15, 1907 :

| | | |
|---|---|---|
| April | 55 | barrels. |
| May | 83 | " |
| June | 60 | " |
| July | 63½ | " |
| August | 18 | " |
| September | 14 | " |
| October | 6 | " |
| Total | 299½ | barrels. |

## The Location of Fish-Traps within the Waters of Narragansett Bay, and the Collection of Data Bearing upon their Ownership.

The collection of data under this head was begun in 1898, when there were already more than one hundred traps in the Rhode Island waters exclusive of Block Isand. For ten years our reports have published charts showing the position of the traps and a table indicating their ownership. The table giving the summary for the ten years is interesting in showing the steady increase in number of traps in various locations and as a whole.

The increase in the number of traps includes the year 1907. It is particularly noticeable in the offshore traps, where the number has doubled in the last three years. During the scup season a cordon of these large traps is spread about the mouth of the Sakonnet river. To form the outer edge of this cordon, traps, each with a leader one-half mile long, are stretched in a nearly perfect arc from Seal Rock to a point south-southeast of Sakonnet Light. The remaining traps are interspersed within this arc in such a way as to fill up the gaps in the outer row. (See chart.)

## FISH TRAPS SET IN RHODE ISLAND WATERS AND LIST OF TRAP OWNERS.

### Table Showing Number and General Distribution of Fish-Traps Since 1898.

The following arbitrary divisions have been made for the sake of convenience:

I. *Providence River.*—South to a line joining Warwick Point and Popasquash Point.

II. *Greenwich Bay.*—South of Providence River division in west passage to a line drawn east and west touching southern part of Hope Island.

III. *West Passage.*—The west passage south of Greenwich Bay region to a line drawn due west from Beaver Tail and west of a line connecting the east end of Greenwich Bay boundary and North Point.

IV. *Mount Hope Bay.*—North of railroad bridge, Tiverton, and a line connecting Bristol Ferry and Muscle Shoal Light.

V. *East Passage.*—South of Providence and Mount Hope Bay divisions and north of a line from Beaver Tail to Brenton's Point.

VI. *Sakonnet River.*—The Sakonnet river south of railroad bridge to a line connecting Flint Point and the breakwater.

VII. *Off Shore.*—Traps south of above divisions and not off Block Island.

VIII. *Block Island.*

| YEAR. | Providence River | East Greenwich. | West Passage. | Mount Hope Bay. | Sakonnet River. | East Passage. | Off-Shore. | Block Island. | Total. |
|---|---|---|---|---|---|---|---|---|---|
| 1898 | 4 | 6 | 26 | 9 | 34 | 15 | 25 | ...... | 119 |
| 1899 | 3 | 10 | 23 | 11 | 35 | 15 | 24 | ...... | 121 |
| 1900 | 4 | 16 | 24 | 16 | 34 | 12 | 29 | ...... | 135 |
| 1901 | 7 | 15 | 24 | 13 | 52 | 14 | 26 | ...... | 151 |
| 1902 | 6 | 22 | 27 | 13 | 52 | 14 | 27 | ...... | 161 |
| 1903 | 7 | 21 | 32 | 13 | 72 | 16 | 30 | ...... | 195 |
| 1904 | 6 | 27 | 33 | 7 | 78 | 14 | 49 | 6 | 220 |
| 1905 | 6 | 26 | 33 | 11 | 82 | 20 | 56 | 6 | 240 |
| 1906 | 6 | 35 | 27 | 11 | 80 | 20 | 64 | 6 | 249 |
| 1907 | 7 | 37 | 30 | 12 | 87 | 22 | 70 | 6 | 271 |

Compiled by E. W. Barnes, A. M.

## 1907.

### LIST OF TRAPS AND OWNERS.

*Off-Shore Traps.* (*See Charts.*)

| | |
|---|---|
| Anderson, C. A. | South Cormorant Rock. |
| Anderson, C. A | South Sakonnet Light. |
| Anderson, C. A | South Narragansett Pier. |
| Anderson, C. A | South Seal Rock. |
| Atlinger, C | Breakwater, Point Judith. |
| Brightman, W. (00)* | Seal Ledge. |
| Brightman, W | South Sakonnet Light. |
| Brightman, W. (00) | Below Cormorant Rock. |
| Brownell & Church | Coggeshall's Ledge. |
| Brownell, J. | Lower Pier. |
| Brownell, J | North Narragansett Pier. |
| Brownell, J | South Sakonnet Light. |
| Brownell, J. | South Cormorant Rock. |
| Calvert, G. (000) | Spouting Rock. |
| Church, J | South Lower Pier. |
| Church, J | South Ochre Point. |
| Church, J | South Ochre Point. |
| Cottrell, Cottrell, Church & Luther | Coggeshall's Ledge. |
| Cottrell, Cottrell, Church & Luther | Cormorant Rock. |
| Cook, Chas. (00) | North Sakonnet Light. |
| Easterbrooks, C. (00) | Price's Neck. |
| Fisheries Co | Coggeshall's Ledge. |
| Fisheries Co. (000000000) | South Sakonnet Light. |
| Grinnell, F | South Sakonnet Light. |
| Lockinger, H. | South Breakwater. |
| Lockinger, H | Sakonnet Light. |
| Macomber & Simmons | South of Pier. |

* The ciphers indicate the number of traps set in line on one string of leaders.

# NARRAGANSETT BAY.

SHOWING THE LOCATION OF FISH TRAPS FOR 1907.

PREPARED BY THE RHODE ISLAND COMMISSION OF INLAND FISHERIES TO ACCOMPANY REPORT FOR 1907.

| | |
|---|---|
| Macomber & Simmons | Below Coggeshall's Ledge. |
| Macomber & Simmons (00) | South Sakonnet Light. |
| Petty, J | South Cormorant Rock. |
| Providence Fish Co | West Cormorant Rock. |
| Providence Fish Co | South Sakonnet Light. |
| Rose, W | Below Cormorant Rock. |
| Rose, W | South Cormorant Rock. |
| Rose, Geo. (00) | North Sakonnet Light. |
| Rose, Geo. | South Sakonnet Light. |
| Sakonnet Oyster Co. (00) | Seal Rock. |
| Sakonnet Oyster Co | Coggeshall' Ledge. |
| Sousa, G. (000) | Easton's Point. |
| Sousa, G | West Sachuest Point. |
| Tallman, B. (00) | South Cormorant Rock. |
| Tallman, B | South Sakonnet Light. |
| Tew, R | West Price's Neck. |
| Wait, B | Breakwater, Sakonnet. |
| Walsh, J | Southwest Seal Rock. |
| Wilcox, G | West Breakwater, Point Judith. |
| Wilcox, H | South Cormorant Rock. |
| Wilcox, H. (00) | West Cormorant Rock. |
| Wilcox, H | North Sachuest Point. |
| Wilcox, H | Sakonnet Light. |

*Other Traps.*

| | |
|---|---|
| Aldrich, R. (00) | North Point. |
| Aldrich, R. (00) | Quonset Point. |
| Almy, Frank | High Hill Point. |
| Almy, Frank (00) | South High Hill Point. |
| Anderson, C. B | Coddington Cove. |
| Anderson, C. B | Coddington Cove. |
| Baker, C | West Vials Creek. |
| Brayton, G. (00) | North Prudence Park. |
| Brayton, G | Podjac Point. |

| | |
|---|---|
| Brayton, G. (00) | Pine Hill Point. |
| Carpenter, Geo. | South Ferry. |
| Coggeshall, E. (00) | Wood's Castle. |
| Coggeshall, E. | Lower west shore Sakonnet. |
| Coggeshall, E. | South Sandy Point. |
| Coggeshall, E. | North Sandy Point. |
| Corey, Ed. (000) | Lower west shore Sakonnet. |
| Corey, Ed. (00) | Wood's Castle. |
| Corey & Allen (00) | South High Hill Point. |
| Corey & Allen (00) | Brown's Point. |
| Corey & Martin (00) | South High Hill Point. |
| Corey & Martin (0000) | North Brown's Point. |
| Corey & Martin (00) | North Church's Point. |
| Cottrell, S. | West Popasquash Neck. |
| Cottrell, S. | West Papasquash Neck. |
| Cottrell, S. | West Popasquash Point Neck. |
| Cottrell, S. | West Popasquash Neck. |
| Cottrell, S. (00) | Mount Hope Point. |
| Cottrell, S. | South Mount Hope Point. |
| Cottrell, S. (000) | Upper East Sakonnet River. |
| Cottrell, W. (00) | North Tiverton. |
| Falkner, G. | South Portsmouth. |
| Fish, Clinton | North Tiverton. |
| Fish, Clinton | North Tiverton. |
| Fish, Clinton | North Tiverton. |
| Fish, Clinton (000) | McCurry's Point. |
| Gladding, A. B. (00) | Castle Hill South. |
| Gray Bros. (000) | East Hope Island. |
| Gray Bros. (0000) | Prudence Park. |
| Gray Bros | Southwest Prudence Island. |
| Gray, Geo. E. & Co | South Sandy Point. |
| Gray, Geo. E. & Co | North Sandy Point. |
| Gray, Geo. E. & Co. (000) | South McCurry's Point. |
| Grinnell, E. (000) | North Pine Hill Point. |

| | |
|---|---|
| Grinnell, E | Hull's Cove. |
| Harvey, Chas | South Coal Mine, West Shore Rhode Island. |
| Hicks, O. G | Castle Hill South. |
| Howland, J | Island Park. |
| James, Arnold | Taylor's Point. |
| James, Arnold | Jamestown. |
| James, Arnold | Mackerel Cove. |
| Johnson, G | Fox Island. |
| King, Chas | Fogland Point. |
| King & Wait (00) | South McCurry's Point. |
| King & Wait | South McCurry's Point. |
| Lake, Benj. (00) | Fogland Point. |
| Lake, I | West Vials Creek. |
| Lake, I | Northwest Conanicut Island. |
| Lawton, Ed | Mackerel Cove. |
| Lawton, Ed | Mackerel Cove. |
| Lawton, F | Mackerel Cove. |
| Lawton, F | Mackerel Cove. |
| Lawton, F. (00) | Brenton's Cove. |
| Lewis Bros | Packards Rocks. |
| Lewis Bros | West Vials Creek. |
| Lewis Bros. (000) | Wild Goose Point. |
| Lewis Bros. (00) | Dutch Island Harbor. |
| Lewis Bros | North Dutch Island Harbor. |
| Lewis Bros | Sandy Point. |
| Lewis Bros | South Sandy Point. |
| Lewis, Wilson (0000) | North Black Point. |
| Lewis, Wilson (000) | North Sandy Point. |
| Locke, Moses | Buttonwoods. |
| Locke, Moses | South Chepiwanoxet. |
| Locke, Moses (00) | North Chepiwanoxet. |
| Macomber, F. A. (00) | North High Hill Point. |
| Macomber & Rose | North Pine Hill Point. |
| Madison, P. (00) | Northwest Hope Island. |

| | |
|---|---|
| Madison, P. (00) | Northeast Hope Island. |
| Madison, P. (00) | Buttonwoods. |
| Madison, P | Buttonwoods. |
| Manchester, A | South Sandy Point. |
| Manchester, A | North Sandy Point. |
| Manchester, D | Quonset Point. |
| Manchester, D | Vials Creek. |
| Matteson, C | Fox Hill. |
| Matteson, C | Conanicut. |
| Mitchell, E | North Prudence Park. |
| Mitchell, E | South Podjac Point. |
| Northup & Co | Austin's Hollow. |
| Pierce, B. T | South Black Point. |
| Pierce, B. T | North Sandy Point. |
| Providence Fish Co | Off Wood's Castle. |
| Rice, H. H | Warwick Neck. |
| Rice, H. H | Warwick Neck. |
| Rose, Geo | Church's Cove. |
| Rose, Geo | North Mount Hope Point. |
| Rose, Geo | North Mount Hope Point. |
| Rose, Geo. (000) | North Sapowet Point. |
| Rose, Ed | Upper East Shore Sakonnet River. |
| Rose, Ed | South Stone Bridge. |
| Rose, Sam | Upper East Shore Sakonnet River. |
| Rose, Sam (00) | North Sapowet Point. |
| Sanford, J | South High Hill Point. |
| Shepherd, J. (00) | North Point Popasquash. |
| Sherherd, J | Rumstick. |
| Silvia, P. (00) | Flint Point. |
| Sisson, ——— | South Greenwich Bay. |
| Smith Bros | Southeast Prudence. |
| Smith Bros | East Shore Conanicut. |
| Smith Bros | East Shore Conanicut. |
| Smith, W | West Quonset Point. |

| | |
|---|---|
| Smith, W | Poplar Point. |
| Snell, A. (00) | South Sapowet Point. |
| Snell, A | South Sapowet Point. |
| Snell, A | South McCurry's Point. |
| Spink, J. W | North Point Conanicut. |
| Spink, J. W | Southeast Prudence. |
| Taber, J | North Tiverton. |
| Tallman & Boyd | North Castle Hill. |
| Tourgee, P | Austin's Hollow. |
| Tourgee, P | South Saunderstown. |
| Wilcox, H | Church's Cove. |
| Wilcox, H. (00) | High Hill Point. |
| Wilcox, H | Church's Cove. |
| Wilkie, A | South Sapowet Point. |
| Wilson, Al | Buttonwoods. |
| Wilson, Al | South Podjac. |
| Wilson, Al (00) | South Greenwich Bay. |

## The Continued Examination of the Physical and Biological Conditions of the Bay.

Data relating to the character of the shores and sea bottom, the temperature and density of the water, the occurrence of animal and plant life in various places and at various times; facts relating to rare or unusual animals; information about breeding times and habits of fishes and invertebrates, and miscellaneous data of similar character, are continually being gathered together and placed on file. From time to time the Commission has brought together portions of these data in the form of special papers. (See index.)

The present report includes the following special papers:

### THE FISHES OF RHODE ISLAND.

No. V. The Flat-fishes, by H. C. Tracy.

No. VI. A Description of two young Specimens of Squeteague (*Cynoscion Regalis*) with Notes on the Rate of their Growth, by H. C. Tracy.

# THE FISHES OF RHODE ISLAND.*

## V. THE FLAT-FISHES.

BY HENRY C. TRACY, A. M.,

BROWN UNIVERSITY.

The flat-fishes and flounders comprise a group which is in many respects one of the most interesting among the fishes. Their abundance in all seas and their excellent food qualities has long made them of very great value to man. Another factor which contributes greatly to their value to man is their availability; many species of the family find their most natural abode in shallow waters near the shore, where they are easily accessible to all fishermen, even to those who work with the most primitive methods; in most localities, also, one or more species of flat-fishes are present in considerable abundance during every season of the year, and so afford a constant supply of valuable fish. Thus the value of the flat-fishes to man compares very favorably with that of those fishes whose vast wandering schools sometimes furnish immense quantities of fish but which are very irregular in their visitations and subject to great variations in abundance.

The flat-fishes also possess a peculiar interest, since they furnish a striking illustration of the modification of an animal to a certain specialized mode of life. They show how unique may be the direction

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* Previous papers in this series are as follows:

I. A List of the Fishes of Rhode Island, 36th Report, 1905, page 38.

II The Common Fishes of the Herring Family, 36th Report, 1905, page 100.

III. The Fishes of the Mackerel Family, 37th Report, 1906, page 33.

IV. A List of Rare Fishes Taken in Rhode Island in the Year 1906, 37th Report, 1906, page 65.

which changes in form and structure of animals may take in order that they may become adapted to the conditions of their environment. The flat-fishes are exclusively bottom fishes; they are somewhat sluggish in habit, feed mostly on bottom invertebrates, and seldom leave the bottom except for relatively short excursions in the pursuit of food or when disturbed. To a fish of this sluggish mode of life, such an inconspicuousness in appearance as will cause it to be overlooked by its enemies and prevent it from frightening its prey will largely increase its chances of survival. In the case of such bottom fishes as the flat-fishes, and the skates and rays, this advantage is secured partly by a protective coloration, perhaps, and partly by an extreme flattening out of the body of the fish. The skates and rays are flattened in a vertical direction, but the flat-fishes are strongly compressed from side to side; therefore we find in the flat-fishes the unique condition that when in the natural position, whether swimming horizontally through the water or resting on the bottom, their upper and lower surfaces correspond in reality to the sides of other fishes. By this sidewise flattening, the dorsal fin, which runs along the middle line of the back, and the anal fin, which runs along the mid-ventral line, are prominently brought out to the "edges" of the fish and by this relative change in position become capable of being used more directly in forward propulsion than is the case with the unpaired fins of most fishes. Thus it would appear that the problem of producing a powerful means of propulsion in a fish which has to meet the requirements of the structural change demanded by an existence confined almost exclusively to the bottom, has been solved by nature in two different ways, viz.: in the case of the skates and rays, by bringing about a great extension of the pectoral fins as a result of a very considerable vertical compression (this is accompanied by an almost complete disappearance of the unpaired fins); and in the flat-fishes, by a mechanical adjustment resulting from an extreme lateral flattening, which gives a great mechanical advantage to the unpaired fins. The whole of the flat posterior portion of the body, as well as the broad, strong tail-fin, is used also

in forward propulsion. The greater efficiency of the swimming apparatus which results from the lateral compression may be a partial explanation of the greater speed in swimming and the greater precision of movement which the flat-fishes show as compared with the slow, clumsy, lumbering movements of the skates and rays.

This sidewise flattening of the fish and the fact that the fish in its natural horizonital position must have one of its sides constantly turned away from the light involve considerable modifications in its structure. The unpaired fins increase in extent and area to the degree corresponding to their increased importance in propulsion; the dorsal fin extends forward onto the head nearly down to the snout; the body cavity becomes so shortened that the anus is shifted much further forward, and thus the anal fin is brought to extend along all except a comparatively small fraction of the ventral edge of the fish. The area of these fins is also increased by a lengthening of the fin-rays. The paired fins, in most species, since from their position they are of comparatively little use to the fish, have become reduced or wanting. The tail-fin in many species has become increased in area and strengthened by a hypural bone. Changes in pigmentation also occur; the pigmented area in most species is entirely confined to the upper or light-exposed side, while the whole under side becomes colorless like the ventral side of other fishes. The color of the upper side is capable of considerable variation from light to dark according to the prevailing shade of the background.

The mouth parts in some of the species have undergone changes. In the fishes of the Turbot and Halibut tribes the jaws remain unaffected by the change in position of the fish; in these, the mouth is large, symmetrical, toothed around the whole border, and does not partake of the twist of the remainder of the head. In the Flounder tribe (*Pleuronectinæ*), that part of the mouth which belongs to the eyed side has become somewhat contracted and twisted, but on the under side the jaws remain straight and normally toothed. In the case of the soles, the mouth has become very asymmetrical

and much distorted toward the blind side, and the teeth are very small or obsolete.

The most remarkable of the structural changes which accompany the sidewise modification of the body of the flat-fishes are the changes which result in bringing the eye which normally belongs to the side turned toward the bottom over onto the side that is exposed to the light. Both eyes, therefore, come to lie on the upper side of the head; the fish thus loses its bilateral symmetry, and the head acquires its peculiar twisted appearance. These changes are not confined to the eye merely, but involve a considerable torsion of the bones of the head, and an asymmetry of the nerves connected with the displaced parts. These aspects of the asymmetry will be very briefly referred to later, but for details, reference must be made to special papers which deal with the osteology of the flat-fishes.

The degree of asymmetry in the different species is an adaptation correlated with their habits. Those fishes like the halibut, sand-dab, and summer flounder, which are the more free-swimming, and which feed to a considerable extent on other fishes, are the more symmetrical; the displaced eye is nearer the line of the profile, and the mouth parts of the two sides are scarcely different. In the forms like the winter flounder, which live more upon the bottom and in the shallow water and which subsist largely on the bottom invertebrates, and eat other fishes very little, the asymmetery of the eyes has gone further, while the mouth has become twisted toward the under side, and those portions of the jaws which are on the upper side remain relatively undeveloped. It is in the soles that the asymmetry of both eyes and mouth has gone to its greatest extreme. These fishes live on the bottom almost entirely, and probably obtain most of their food by grubbing in the mud. The mouth in this species has become very much twisted. From these facts it may be inferred that the asymmetry of the mouth is independent and secondary to that of the eyes. The asymmetry of the eyes is the result of the need of having both eyes on the side toward the light, while the asymmetry of the mouth is a

secondary adaptation to different external conditions and to different methods of securing food.

The process by which the asymmetry of the eyes is reached in the course of the development of the individual is an interesting one.

Young flat-fishes, when first hatched out from the egg, are symmetrical, and swim upright. A little later, while the bones of the head are still in a cartilaginous condition, the fish turns over on one side, and in the course of a few days the eye of the under side has moved clear around so as to take up its position on the upper side. The details of this transformation have been a subject of a lively controversy for the last half century. Steenstrup (1863) first studied the migration of the eye; he described it as sinking in through the tissues of the head and coming out on the other side. Malm (1868) maintained, on the contrary, that in the species observed by him the eye which belonged to what was to become the under side of the fish, moved over the profile of the head to take its position on the upper side. After some years of controversy it was found by Alexander Agassiz, and others, that both these early investigators were right, and that each had described the process as it actually seemed to take place in the species with which he was working. It has, however, now been established that the process does not essentially differ in either case; according to this view, the asymmetry of the head is not primarily due to the mere migration of the eye from the under side of the head, but is the result of a twisting of the whole ocular region of the head and involves an extensive torsion of the bones of the orbital and preorbital region. The process has been described as follows: "the whole of the cranium in the region of the orbit rotates on its longitudinal axis until the two eyes instead of occupying a horizontal plane have assumed a vertical one"* and one eye is dorsal to the other. At least this seems to be true for species in which the development has been completely worked out. If, at the time of metamorphosis, the dorsal fin does not extend down over the frontal region of the head,

* Cole and Johnstone, Pleuronectes, L. M. B. C. Memoirs, 1901, 9.

the torsion of the cranium carries the eye over the line of the profile; in other species the dorsal fin has already extended down to the snout before metamorphosis has taken place, and in this case the eye has to pass under the tissues supporting the forward extension of the dórsal fin and thus seems to pass from side to side through the head.

The attempts to explain how these unique modifications in the flat-fishes were brought about, probably originated with Lamarck nearly one hundred years ago. As he was the first to conceive and apply systematically a thoroughgoing theory of descent, no one before him had ever recognized that there was any such problem as the origin of the flat-fishes. In accordance with his theory of "use and disuse," he considered that the shifting of the position of the flat-fishes was due to the fact that they acquired the habit of living in shallow water, and then were forced to swim on their sides in order to follow their prey near the shore; the eye on the lower side, as the result of the constant straining upward toward the light, finally, in the course of many generations, migrated over to the other side. A very similar explanation has been recently offered by Cunningham (1897). "The action of the eye-muscles would probably have some effect [in twisting the orbital region], and the weight of the fish, resting on the ground, would force the lower eye-ball toward the upper side, and so distort the face. In all probability both these influences have contributed to the result." *He also suggests an explanation of the forward extension of the median fins on the same basis; the constant action of the numerous small muscles attached to the fin-rays in the young fish would tend to differentiate an increasing number of rays from the embryonic tissue "while the direction of the muscular strains, the constant endeavor by muscular contraction to draw forward the anterior ends of the fins, would determine the direction of their extension. Thus the mode in which the fins were used would produce in the course of generations the structure and relations which they now possess." There are various

* Cunningham, Science Progress, 6. 1897, 502-3.

objections to these hypotheses. Cole and Johnstone,* in an exhaustive paper on the anatomy and osteology of the Plaice (*Pleuronectes*), have shown that the mechanical relations existing between the eye muscles and the bones of the frontal and prefrontal region are such that the contraction of the eye-muscles could not have caused the facial asymmetry. The suggestion that the weight of the body of the fish when turned over on its side aided in pushing the eye over onto the other side, apparently can not be invoked to explains the appearance of asymmetery in the development of the individual, at least, since there seems to be no particular tendency on the part of the larval fishes to turn over on its side until after the eye has begun its migration. This is true of some species at any rate, for Williams† states that the specimens which he captured and kept in the laboratory during the metamorphosis showed in resting no preference for either side until the eye was near the mid-line. If it seems unlikely that larval fishes could have been modified in this way, it seems even more improbable that the hypothetical symmetrical ancestor in the adult form when the bones and other structures had become fixed should have become modified in any such way. Objections of a more general nature against the above explanations are the objections which can be alleged against any theory involving the assumption of the inheritance of acquired characters, but such detailed criticisms of this theory of course have no place in this paper.

The question of the origin of the modifications of the flat-fishes inevitably involves the general theories of evolution. Here it will be possible, to consider only very briefly, the bearing of these theories upon this problem. The development of the flat-fish, as briefly outlined above, shows that the asymmetery does not express itself outwardly until some days after the fish is out of the egg, yet there is evidence which seems to substantially sanction the inference that for its origin in ontogeny, the asymmetry goes back to the germ. That there is some real difference between the organization of the

* Op. cit.

†Reference to the work cited will be found in the foot-note to page 79.

eggs of the right-handed species and those of the left-handed species is shown by the fact that the eggs of most of the right-sided species have no oil-globule, while the eggs of most of the left-sided species have a single oil-globule. This applies to the Flounder family only, and is not true of the Soles (*Solidæ*). It is difficult to imagine that the presence of the oil-globule has any reference to the external conditions, since the eggs of all the species of flat-fishes (except those of the Winter Flounders *Pseudopleuronectes*) are pelagic and, therefore, apparently at least, subject to similar sonditions. This apparent relation between right and left-sidedness and the presence of the oil-globule may, of course be a mere coincidence, yet the facts are so striking that it does not seem to be doing violence to reasonable inference if we believe that such a coincidence is a significant one and based on a real difference in germinal structure. If this is true, then the asymmetry of the fish must be inherent in the germ.

There is another line of evidence, of much greater force, which seems to point unquestionably to the germ as the source of these modifications. The relation of the optic nerves in the chiasma in fishes has been studied by Prof. G. H. Parker. In the bony fishes the optic nerves cross each other in the chiasma without any intermingling of fibers. In the ordinary bony fishes it is apparently a matter of chance whether the right or left nerve is above the other in the chiasma. In 1,000 specimens of ten common species, 486 had the left nerve uppermost and 514 the right nerve. In individual species, similar figures hold true; for example in the haddock, 48 had the left nerve uppermost, and 52 the right nerve. In the flounders, however, a different law holds true and the arrangement of the nerves in the chiasma is not a matter of indifference. Of flounders with eyes on the left side, 131 individuals, representing nine species, all have the right nerve uppermost. Two hundred and thirty dextral flounders, representing sixteen species, had the left nerve uppermost. This is not true of the soles, however; in them the arrangement of the chiasma is apparently a matter of chance as in other bony fishes and has no relation with the asymmetry of the

fish. But in the case of flounders, it seems to be always true that the optic nerve growing out to form the eye that is later to migrate over to the other side always passes above the other in the optic chiasma. The only exception to this is in the case of reversed flounders in which the relation of the nerves in the chiasma conforms to that of the species and does not deviate with the exceptional reversal. The case seems to be analogous to that of some of the snails in which it is possible to trace the asymmetry back to the eight-celled stage of the embryo, except that here, at the present time at least, it is not possible to demonstrate the asymmetery at nearly so early a stage.

It is the necessary implication of the Lamarckian hypothesis that the adaptative modifications acquired through "use and disuse" must appear in, and, originally at least, have their source in, that stage in the development of the individual which is affected by the change of environment; the "use and disuse" of an organ or part would not be called into play in any other stages, and so could not directly produce modifications in them. Thus, in the case of flat-fishes, the change to a bottom existence takes place after the free-swimming stage has been assumed. Their modifications must be adaptations to conditions of life first encountered in that stage and can not be referred back for their origin to any earlier stage or to the germ. Of course we must allow that the potentiality of producing the modifications of the late stages must be present in the earlier stages and in the germ, though there is no apparent reason for assuming that the modifications themselves are projected back to any earlier stage than that at which they are called out by the reaction to the environment. No germinal modifications arising in the egg itself is demanded in this case, for it encounters no new conditions because the eggs of all flat-fishes (with one exception) are pelagic and, therefore, subject to conditions which, as far as we can see, are not different from those of many other fishes. Lamarckian theories, then, as applied to the flat-fishes, must be considered to imply that the modifications found in the adult have been superposed

upon the original symmetrical constitution of the fish at some time in the larval stage as a result of conditions acting on that stage. If we look to the germ, then, we should find in it no evidences of asymmetery, if the Lamarckian theory be the true hypothesis. But, on the contrary, evidence adduced above has shown that there is an asymmetry in the egg which could not have been produced by external forces and which appears at so early a stage that it could not have been produced by the direct effect of "use and disuse." The argument of the Lamarckians, in order to escape from this difficulty would be, of course, that the modifications of the larval and adult stages, which had become fixed by the cumulative effect of repeated actions, became reflected back into earlier and earlier stages until finally the germinal organization itself had become definitely and permanently affected. Of course there is no evidence at present known which will enable anyone to deny positively that such might be the case or that it might thus be capable of explaining the facts in question, but it would certainly seem that the theory would have to be stretched beyond its limits if we are required to believe that if a flat-fish turns over on its right side until the tendency became fixed, the effect of this process on the germinal structure would be to produce an oil-globule in the egg, while if the fish turns over on its left side through a sufficient number of generations, the effect is such as to produce no oil-globule in the egg. It is scarcely less difficult to admit that the asymmetry having become fixed in the larva and adult stages as a result of voluntary attempts at adaptation through a series of generations might become reflected back into such a very early period in the germ as to affect the direction of the growth of the eye-stalk which, at any time, is only indirectly affected by "use and disuse" and only at a very much later stage. But even if we admit this as a possibility, it seems difficult to reconcile this hypothesis with the condition found in the soles, in which the asymmetry has gone considerably further, but has not been able to bring about any constant relation of the optic nerves in the chiasma.

Thus the Lamarckian explanations of the asymmetry of the flat-fishes seem to be difficult to accept, since the necessary mechanical requirements are not met by the bone and muscle arrangements of the head, and because it is difficult to consider the "use and disuse" theory as accounting satisfactorily for the evidences of asymmetry in the germinal organization. The more fundamental difficulties which are inherent in any Lamarckian hypothesis would, if it were possible to consider them here, give still greater force to these objections. It is sufficient to say that the lack of evidence in support of alleged cases of inheritance of acquired characters gives such force to the *a priori* objections to that theory that, on general grounds alone, we would be justified in rejecting Lamarckian explanations of the origin of the modifications of the flat-fishes.

A much more satisfactory hypothesis to account for the structural modifications of the flat-fishes is that furnished by the theory of natural selection. This theory as applied to the flat-fishes can be accepted at the present time with much better grace than was possible before the theory of mutation had been suggested. The flat-fishes present a problem which is an excellent example of a class of cases which have long been a *bête noir* to the theory of natural selection. It has not been easy, previously, to understand how slight tendencies of symmetrical fishes to assume other than the upright position could confer upon their possessors such advantages in the struggle for existence that natural selection could have been an effective factor in causing their survival. But according to the mutation theory we may assume that a considerable degree of the characteristic modification of flat-fishes was produced all at once as a result of some alteration in the structure of the germ cell; this is consistent with the facts of the case, since evidence adduced above indicates that we are to look for the source of the origin of these characters in the germ cell. These changes or mutations might be great enough to make the new form differ from the old so far that it was enabled to secure a somewhat greater advantage in the struggle for existence by becoming more closely adapted to a bottom existence

than the old forms and thus to appropriate for itself a hitherto unclaimed field for its home. Thus natural selection could act and allow the new forms to become permanent. These early modifications having been established, further changes then may be assumed to have arisen by continued mutation and become fixed by natural selection and ultimately to have produced the great variety of existing species and their adaptation to the varying conditions of bottom existence.

According to this theory, the ultimate source of the modifications of the flat-fishes is to be looked for in the germ cell and in the unknown factors which caused essential changes in the germinal structure of the egg of the symmetrical ancestor of the flat-fishes. Just what this change was, to what cause it was originally referable, how the structure of the germ-cell of the asymmetrical fishes differs from that of the symmetrical fishes, such questions must be left until the theory of evolution by mutation has so far advanced that it can show how mutations result from the conditions which influence germinal structure.

From the systematic point of view, the flat-fishes are grouped together as a suborder called the *Heterosomata*; they are further divided into two families, the Flounder family (*Pleuronectidæ*) and the Sole family (*Solidæ*). The so-called American Sole is the only common representative of the Sole family in American North Atlantic waters; all the other common flat-fishes belong to the Flounder family. The species belonging to the Flounder family may be grouped into three sub-groups or tribes, the Halibut tribe (*Hippoglossinæ*), the Flounder tribe (*Pleuronectinæ*), and the Turbot tribe (*Psettinæ*). Their classification may be put into synoptic form as follows:

- HETEROSOMATA. (The Flat-Fishes.)
  - PLEURONECTIDÆ. (The Flounders.)
    - HIPPOGLOSSINÆ. (Halibut, Summer Flounder, Four-spotted Flounder, Rusty Dab.)
    - PLEURONECTINÆ. (Winter Flounder, Rusty Flat-Fish.)
    - PSETTINÆ. (Window-Pane.)
  - SOLEIDÆ. (The Soles.)
    - ACHIRINÆ. (American Sole).

The ancestry and kinship of the flat-fishes are wholly uncertain. They have usually been placed with the cod-fishes, and it has been assumed that both these groups have descended from some common or nearly related form; it is, however, with much reason that Dr. Boulenger has recently called attention to the close relationship of the flat-fishes to the Zeoidea (the John Dories, or Zeus-like fishes), and he suggested that both these types may have descended from a common stock.

There are some interesting facts regarding the geographical distribution of the various species of the flat-fishes. The fishes of the Flounder tribe (*Pleuronectinæ*) and almost all of the Halibut tribe (*Hippoglossinæ*) are arctic and antarctic in their distribution; the species belonging to the Turbot tribe (*Psettinæ*) are nearly all confined to warm water. Since all the fishes of the Turbot tribe, and those of the Halibut tribe which are found in warm water are left-sided species, while the cold-water halibuts and all of the Flounder tribe are right-sided species, it follows that nearly all the warm-water flounders are left-sided species and the cold-water flounders are right-sided. This peculiar relation may be a coincidence merely, but it is certainly very remarkable that we should find the Summer Flounder and the Four-Spotted Flounder and a few other species of that group to be left-sided and in warm water, while the majority of the fishes of that tribe are right-sided and inhabit cold

water, and that this should agree exactly with the conditions in the Turbot tribe, on the one hand, and the Flounder tribe on the other. There are some of the Californian flat-fishes which, as we might perhaps expect, may perhaps be considered to form transition groups; some species of those waters are right-sided and some are left-sided, and in some species it seems to be true that the fishes are indifferently right or left, or at least reversed individuals are common. These interesting facts suggest to us that natural selection may favor sinistral fishes in the tropics and dextral fishes in cold water. It is difficult to imagine this, though right- and left-handedness may be dependent on conditions in the environment of which we know nothing.

Another remarkable condition is the relation which seems to exist between the number of vertebræ possessed by the various species and their grographical distribution. It is true of other groups of fishes that in some cases their northern representatives have an increased number of vertebræ, but this relation is shown in a strking way in the Flounder family. The following are the averages of the numbers of vertebræ found in the species of the three tribes of the Flounder family:

Flounder Tribe (*Pleuronectinæ*).

Average number of vertebræ in 13 species, 42.

All these species live in northern waters.

Halibut Tribe (*Hippoglossinæ*).

Average number of vertebræ in 15 species, 41.

Of these 15 species, 4 are cold water and 9 occur along the Californian and Middle Atlantic and Gulf Coasts.

Turbot Tribe(*Psettinæ*).

Average number of vertebræ in 20 species, 34.6.

These are tropical or sub-tropical species.

The causes of this remarkable relation are not fully understood. It has been suggested that the reduction in the number of vertebræ of the warm-water species is a result of the higher specialization demanded of those fishes living in the tropics where the struggle for

existence is more strenuous, because of the greater abundance of life in those waters.

In Rhode Island waters are found eight species of flat-fishes which represent the chief groups of the suborder *Heterosomata*. The technical description of the tribes, genera, and species follows:*

**A. PLEURONECTIDAE.** The Flounder Family.

Preopercula margin distinct, and not hidden by scales; eyes large and well separated; mouth large or moderate; teeth present.

I. HIPPOGLOSSINÆ. The Halibut Tribe.

Large mouthed flounders with ventral fins symmetrical; jaws and teeth neary equal on both sides. Pectoral and ventral fins well developed, the ventral fins similar in position and in form of base, the ventral fin of the eyed-side and not being attached along the ridge of the abdomen.

HIPPOGLOSSUS. Halibut.

Eyes and color on the right side. Form oblong, not strongly compressed. Mouth wide, oblique; teeth in the upper jaw in two series, those below in one; anterior teeth in upper jaw and lateral teeth in lower, strong; no teeth on vomer or palatines; lower pharyngeal teeth in two rows. Dorsal fin beginning above the eye, its middle rays elevated, the posteral rays of dorsal and anal bifid; cordal fin lunate; ventral fins both lateral. Scales very small, cycloid; lateral line arched in front. Gill rakers few, short, compressed, wide set, vertebræ 16+34. Largest of the flounders.

**1. Hippoglossus hippoglossus.** *The Halibut.*

Body elongate, not strongly compressed, deep mesially; head broad; eyes large, separated by a very broad flattish area; the lower eye slightly advanced; mouth large, maxillary reaching middle of orbit. Depth of body one-third its total length; head moderately

*The technical description of these fishes has been taken from "The Fishes of North America," by Jordan and Evermann.

long, its length contained $3\frac{3}{4}$ times in total length. D. 105; A. 78; P. 19; V. 6; scales 150+. Color, nearly uniform dark brown; blind side white.

## HIPPOGLOSSIDES.

Eyes and color on the right side. Body oblong, moderately compressed; mouth rather large, with one row of sharp teeth on each jaw; no teeth on vomer or palatines; gill rakers rather long and slender; scales ctenoid; lateral line straight; dorsal fin low in front, beginning over or before the eye; ventrals both lateral; caudal double truncate, produced behind.

2. **Hippoglossoides piatessoides.** *The Rough Dab.*

Body ovate; mouth moderate, oblique; maxillary narrow, reaching to below pupil, $2\frac{2}{3}$ in length of head; teeth rather small, conical, larger anterior in one row in each jaw, those in the lower largest. Eyes rather large; the lower jaw included, but with a projecting knob at the chin; snout thick, scaly. Interorbital space narrow, with a raised obtuse ridge entirely covered with rough scales in about six series; mandible with a series of scales; gill rakers rather short and robust, not toothed, about ten below angle, the longest less than one-third length of eye; fins with small, rough scales; a strong preanal spine; pectoral not quite one-half length of head. Head contained $3\frac{3}{4}$ times in length of body; depth, $2\frac{1}{2}$ times in body. D. 88; A. 70; scales 90 (pores). Color reddish brown, nearly plain.

## PARALICHTHYS.

Eyes and color on left side. Body oblong; mouth large, oblique; each jaw with a single row of usually slender and sharp teeth, which are more or less enlarged anteriorly; no teeth on vomer or palatine. Gill rakers slender. Scales small, weakly ctenoid or ciliated; lateral lines simple, arched anteriorly. Dorsal fin beginning before the eye, its anterior rays not produced; both ventrals lateral;

caudal fin double truncate, or double concave, its middle rays produced; no anal spine.

**3. Paralichthys dentatus.** *The Summer Flounder.*

Head contained $3\frac{1}{2}$ to 4 in body; depth 2 2-5; caudal $1\frac{1}{4}$. D. 86–91; A. 65–71; lateral line 108 (tubes). Body ovate; maxillary reaching past posterior margin of eye; mouth large, oblique, the gape curved. Canines large, conical, wide set; gill rakers comparatively long and slender, longest two-thirds eye, 5 + 15 to 6 + 18 in number; interorbital area a rather flattish ridge, in the adult about equal to vertical diameter of eye, narrower in the young, forming a bony ridge; scales cycloid, each with numerous small accessory scales; vertebræ 11 + 30. Color in life, light olive brown; adults were very numerous, small white spots on body and vertical fins; sometimes a series of larger white spots along basis of dorsal and anal fins; about 14 ocellated dark spots on side, these sometimes little conspicuous, but always present; a series of four or five along base of dorsal, and three or four along base of anal, those of the two series opposite, and forming pairs; two pairs of smaller less distinct spots midway between these basal series and the lateral line anteriorly, with a small one on lateral line in the center between them; a large distinct spot on lateral line behind middle of straight portion; fins without the round dark blotches.

**4. Paralichthys oblongus.** *Four-spotted Flounder.*

Head contained four times its body; depth $2\frac{1}{4}$ of body. D. 72; A. 60; Scales 93. Body comparatively elongate, strongly compressed. Eyes large, nearly four in head, separated by a prominent, narrow, sharp ridge. Upper jaw with very numerous small, close-set teeth laterally, and four or five canines in front; the lateral teeth abruptly smaller than the anterior; each side of lower jaw with seven to ten teeth. Chin prominent. Maxillary narrow, reaching past middle of pupil, $2\frac{1}{4}$ in length of head. Gape curved; gill rakers short and toothed behind, 2 + 8. Scales weakly ctenoid or cycloid.

Dorsal low, beginning over front of eye, some of the anterior rays exserted, but not elongate the longest rays behind middle of fin, not quite one-half head; anal spine obsolete. Grayish, thickly mottled with darker and somewhat translucent; four large, horizontally oblong, black ocelli, each surrounded by a pinkish area, one just behind middle of the body below the dorsal, one opposite this above anal, two similar smaller spots below last rays of dorsal and above last of anal.

### II. PLEURONECTINÆ. The Flounder Tribe.

Mouth small, unsymmetrical, the jaws on the eyed-side with nearly straight outline, the bones on the blind strongly curved; dentition chiefly developed on the blind side; eyes large; pectoral fins well developed; vertical fins well separated; ventral fins nearly or quite symmetrical, that of the eyed-side not prolonged along the ridge of the abdomen; anal spine usually strong. Body dextral.

### LIMANDA.

Teeth chiefly uniserial; lateral line with a distinct arch in front, and without accessory dorsal branch; scales imbricated, rough ctenoid; vertebræ about 40. Differs from *Pseudopleuronectes* by the arch in the lateral line.

**5. Limanda ferruginea.** *Rusty Dab.*

Head 4 in length, depth 2 1-5. D. 85; A. 62; Scales 100. Body ovate-elliptical, strongly compressed; teeth small, conical, close-set, in a single series on each side in each jaw, about 11 + 30 in the lower jaw; snout projecting, forming a strong angle above upper eye, with descending profile; gill rakers of moderate length, very weak, not toothed; eyes moderate; the lower slightly in advance of upper, separated by a high very narrow ridge, which is scaled posteriorly, and is continued backward as an inconspicuous but rough ridge to the beginning of the lateral line; scales imbricate, nearly uniform, those

on the right side rough ctenoid, those on the left side nearly or quite smooth; scales on body rougher than cheeks; caudal peduncle short, higher than long; dorsal inserted over eye, its middle rays highest; pectoral less than two-fifths head; caudal rounded; anal spine present; lateral line simple, with a rather low arch in front; a concealed spine behind ventrals; ventral of colored side partly lateral, the other wholly so; anal spine strong. Brownish olive, with numerous, irregular, reddish spots; fins similarly marked; left side with caudal fin, caudal peduncle, and margins of dorsal and anal fins lemon yellow.

## PSEUDOPLEURONECTES.

Body oblong; the scales firm, strongly ctenoid on eyed side in both sexes; fin rays scaly; mouth small; teeth uniserial, incisor-like, close set, all more or less blunt; the lower pharyngeals very narrow, each with two rows of separate, conical teeth. This genius is distinguished from *Limanda*, which it closely resembles, by the want of arch in the lateral line.

### 6. **Pseudopleuronectes americanus.** *The Winter Flounder.*

Head four times in length; depth $2\frac{1}{4}$. D. 65; A. 48; Scales 83. Body elliptical; an angle above eye. Head covered above with imbricated, strongly ctenoid scales, similar to those on the body; blind side of head nearly naked; interorbital space rather broad, strongly convex, its width one-half eye, entirely scales; teeth compressed incisor-like, widened toward tips, close set, forming a continuous cutting edge; some of teeth often emarginate, sometimes movable; right side of each jaw toothless. Highest dorsal raised less than length of pectorals, and more than one-half length of head; anal spines present. Dark rusty brown, spotted or nearly plain; young are olive brown, more or less spotted and blotched with reddish.

## III. PSETTINÆ.

Large mouthed flounders, with the ventral fins unsymmetrical. Mouth symmetrical; gape wide; lower pharyngeals narrow, with

rows of small sharp teeth; teeth on jaws, acute; eyes not minute; pectorals and ventrals well developed; ventral fins dissimilar in form and position, that of the left side inserted on the ridge of the abdomen, its base extended along this ridge, its rays more or less wide apart; vertebræ in moderate or small number, 31 to 45. Body sinistral. Species chiefly tropical or subtropical.

## LOPHOPSETTA.

Eyes and color on the left side. Body broadly ovate, strongly compressed, pellucid; mouth large, oblique, the maxillary reaching to beyond eye; teeth subequal, in narrow bands, or in single series; a small patch of teeth on the vomer. Scales small, cycloid, imbricate, the skin without bony tubercles. Lateral line strongly arched in front, without accessory branch. Dorsal fin beginning on the snout, its anterior rays exserted; anal fin not preceded by a spine; ventral of left side free from anal inserted nearly on the ridge of the abdomen, its base broad, the rays well separated; pectoral and ventral fins moderate. Nearly related to the European genus *Bothus*, and to the European Turbot, *Psetta*.

### 7. **Lophopsetta maculata.** *The Window Pane* or *the Sand Dab.*

Head $3\frac{1}{2}$ in length; depth 1 3-5. D. 65; A. 52; Scales 85. Body broadly rhomboid, strongly compressed, translucent in life; mouth large, the maxillary reaching nearly to posterior margin of eye, maxillary of eyed side with a bony tubercle on its anterior end; jaws subequal, the lower with a sharp knob at symphysis; teeth in each jaw in one series laterally, in a very narrow band in front; interorbital space rather broad, slightly concave, its posterior third or fourth with scales; gill rakers short and slender, about 8 + 25; maxillary, mandibles, snout, and the greater part of interorbital naked; scales on head and body cycloid, loosely imbricated, those on the blind side a little smaller. Anterior rays of dorsal produced, their ends branched and free, the first on tip of snout, the rays at the beginning

of posterior third of fin the highest; origin of anal directly under angle of preopercle; base of ventrals long, that of the eyed side extending along ridge of body from notch in isthmus to front of anal, base of ventral on blind side shorter; pectoral reaching past curve on eyed side, its mate much smaller; cordal rather long. Color light olive brown, almost translucent, everywhere marbled with paler, and with many small, irregular, sharply defined black spots; dorsal, anal, and caudal with larger, round, blended spots of dark brown; pectoral with brown, interrupted cross lines.

## B. SOLEIDAE.

Body oblong or elongate, usually scaly; mouth very small, much twisted toward the eyed side; the teeth in villiform bands, very small or obsolete; eyes small, close together, with or without a bony ridge between them; edge of preopercle adnate, concealed by the skin and scales; the gill openings narrow, the gill membranes adnate to the shoulder girdle above; pectoral fins small or wanting; ventral fins small, one or both sometimes wanting. Vertebræ usually in increased numbers. Similar to the *Pleuronectidæ* in structure, but much degraded, the fins and teeth having lost many of their distinctive qualities. They are naturally divisible into three subfamilies, each quite distinct from the others, and possibly independently descended or degraded from normal *Pleuronectidæ*.

### ACHIRUS.

Eyes and color on the right side. Body oblong, bluntly rounded anteriorly. Head small; eyes small, close together, the upper eye in advance of the lower, the two separated by a bony ridge; mouth small, somewhat turned toward the colored side; nasal flaps present, the nostril of the blind side fringed; lip of the colored side fringed; teeth very small, on blind side only; the gill openings rather narrow, but confluent below, not reduced to a slit; the branchiostegal region scaled. Head closely scaled everywhere; scales on the blind side

anteriorly with their pectinations more or less produced forming cirri; scales with both sides extremely rough, extending on the fins. Lateral lines straight, simple; edge of preopercle covered by the scales. Dorsal beginning on the snout, low in front and thickly scaled, its rays divided; anal fin similar without spine; caudal fin convex; caudal peduncle very short and deep; pectoral fin of left side wanting, that of right side small or obsolete; ventral rays three or four, the ventral fin of the colored side long, connected with anal by membrane.

### 8. **Achirus fasciatus.** *The American Sole.*

Head 4 in body; depth 1 4-5. D. 50–55; A. 37–46; Scales 66–75. Body broad, irregularly elliptical; mouth moderate, reaching just past front of lower eye; right lower lip fringed; eyes very small, the upper one in advance of the lower; nostril ending in a wide tube, nearer lower eye than tip of snout; interorbital space with scales, more than one-half eye; head and body scaled with strongly ctenoid scales, none of them with hair-like appendages; lateral line nearly straight; gill opening short, about twice as long as maxillary. Origin of dorsal on tip of snout; last few rays of dorsal and anal rapidly decreasing, giving the fins a truncate appearance posteriorly; pectorals wholly wanting; caudal rounded. Color dusky olive, more or less mottled, and with about eight dark, vertical stripes, these varying very much in width and in number; blind side often with round, dark spots, specially northern specimens usually immaculate in southern ones. Vertebræ 8 + 20.

The following artificial key, based on the most obvious external characters, may be useful in distinguishing these species:

## *A.*—RIGHT-SIDED SPECIES.

### I. MOUTH LARGE, SYMMETRICAL.

**1. The Halibut.**

Lateral line with an arch in front; size very large; scales smooth.

**2. The Rough Dab.**

Lateral line straight; scales rough; length 20 inches or less.

II. MOUTH NOT LARGE, UNSYMMETRICAL, AND AT END OF SNOUT.

**3. The Rusty Flat-Fish.**

Lateral line with arch in front.

**4. The Winter Flounder.**

Lateral line straight.

III. MOUTH VERY SMALL, VERY UNSYMMETRICAL, THE SNOUT PROJECTING BEYOND THE MOUTH.

**5. The American Sole.**

Dusky olive in color, mottled, with several dark vertical stripes; the under side usually has a large number of round, dark spots.

## *B.*—LEFT-SIDED SPECIES.

I. VENTRAL FINS NOT ON THE RIDGE OF THE ABDOMEN; BODY OBLONG; COLOR DARK.

**6. The Summer Flounder.**

Color olive brown, profusely mottled with white, dark and ocellated spots.

**7. The Four-Spotted Flounder.**

Color grayish, mottled with darker spots; four large, oblong, black, ocellated spots on posterior half of body.

II. VENTRAL FIN OF LEFT SIDE PLACED NEARLY ON THE RIDGE OF ABDOMEN; BODY OVATE AND EXTREMELY THIN.

**8. The Window Pane or Sand Dab.**

Light olive brown in color, translucent, marbled with paler and with many small dark spots.

The remainder of this paper is intended to present, as fully as space will allow, the most important facts which have been ascertained regarding the life history and life conditions of those individual species of flat-fishes which are present in Rhode Island waters. Pictures of these species are shown in Plates I to IX.*

## THE HALIBUT.

(*Hippoglossus hippoglossus.*)

PLATE I.

I. *Distribution and Habitat.* The natural habitat of the halibut is in the cold water of the northern seas; it is widely distributed along both shores of the North Atlantic and the North Pacific, and it ranges well up into the Arctic regions. The water in which it is most frequently found is never of a higher temperature than 45° F., and often but little above 32° F. The northern limit of its range has never been determined; it occurs along the whole west coast of Greenland, is abundant at Iceland and Spitzbergen, and has been observed on both sides of the North Cape. In the Pacific, halibut are most abundant in the Gulf of Alaska, and they have been taken as far north as Behring Straits. There is no reason for doubting that the southern shores of the Arctic Ocean along both continents

* Plates I to VI and Plate VIII and IX are reproduced from Goode's "Natural History of Aquatic Animals," 1884; Plate VII is reproduced from "American Food and Game Fishes," 1902, by Jordan and Evermann.

are inhabited by this species. Its usual southward range on the European coast is to the English Channel, but stray specimens have sometimes been taken in deep water off the coast of France. On the American coast of the Atlantic, its natural southerly limit is Cape Cod, but occasional individuals wander southward to Sandy Hook. It is said that halibut were formerly quite abundant about Vineyard Sound and Block Island, but for many years they have been very rare south of Cape Cod. There is no record of a capture of a halibut south of Sandy Hook, where several large ones have been captured in winter. On the Pacific coast, they range southward to the Farallones off San Francisco. The geographical range of the halibut coincides closely with that of the cod, though the latter is somewhat less confined to cold, since it ranges 4° or 5° F. further south; the cod, also, in winter is very abundant off the southern shore of New England where the halibut is very rare, while the halibut also strays further out into deeper and colder water than the cod.

In Rhode Island waters only a few instances of the capture of halibut have been recorded in the last quarter of a century. In February, 1876, a few were taken about eight miles from the southeast point of Block Island; on May 1, 1876, off Watch Hill, an eighty-pound halibut was taken, the first in that vicinity for many years; during that same month many halibut were taken about ten miles southeast of Montauk Point; one or two in the last sixty years have been taken off the outer shore of Fisher's Island; on April 16, 1900, a one-hundred-pound halibut was brought to Newport which had been captured with others off Block Island by a cod fisherman.

The normal habitat of the halibut is upon the offshore banks and the edges of the continental slope; it is found in all depths ranging from shoal water near shore out to a depth of three hundred fathoms or more. It seems to be most abundant at considerable depths, from fifty to one hundred fifty fathoms.

In the course of the last century the center of the abundance of this species seems to have shifted many times. A hundred years

ago halibut were exceedingly abundant in Massachusetts bay.* From 1830 to 1850 they were very abundant on George's Banks; since 1850 they have partially disappeared from this region, and the fishermen have been constantly following them to other banks and out into deeper and deeper water. Since 1874 the fisheries have been carried on almost exclusively in the gulleys between the off-shore banks and on the outer edges of the banks in water one hundred to three hundred fifty fathoms in depth.

II. *Migrations.* Very little is definitely known regarding the migrations of the halibut. Throughout the year they are present on the edges of all the banks from George's to the Grand Bank in deep water from a hundred to two hundred and fifty fathoms. Whatever annual migrations they undertake are probably not extensive, but, as far as can be ascertained, are limited to relatively small movements between deep and shallow water according to the seasonal changes of the temperature. The only consideration pointing definitely to such a movement is the fact that during winter and early spring halibut are sometimes found to be more numerous in shallow water. They are also found further south during the colder months of the year, as is shown by the fact that the months from February to May include the only authentically recorded cases of halibut in water south of Cape Cod. This seasonal movement, however, can be only very slight in extent, and apparently does not take place with any regularity.

In the preceding section, mention was made of the fact that there is a larger, more extensive, movement, in which the halibut are moving constantly into deeper and deeper water. The only explanation suggested for this is that the halibut live in large schools, and as soon as they have exhausted the food supply in any particular locality, they move on to fresh feeding grounds. None of their migrations have any apparent connection with their reproductive activity.

III. *Reproduction.* Comparatively little is known with regard

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* Goode, Na. Hist. of Aquatic Animals, 1884.

to the spawning habits of the halibut. The testimony of observers seems to indicate a spawning season in American waters lasting through the summer and into the autumn. On the European coast, according to Cunningham, the halibut spawns from April to August, and the period may extend somewhat in both directions.*

Ripe eggs of the halibut have been seen only rarely, while the fertilized eggs of this species are entirely unknown. McIntosh† describes some fresh and apparently ripe eggs which were taken in May, 1892. Their diameter ranged from 3.07 mm. to 3.81 mm. (3-20 inch). The yolk was colorless and translucent; there was no oil globule. The capsule egg was very thin and collapsable. Another sample of ripe eggs was secured the same year; these averaged from 3.4 mm. to 3.7 mm. in diameter. On the 5th of May, 1893, half a gallon of ripe eggs was obtained from a fish from Bergen Bank; the diameter of these averaged from 3.08 mm. to 3.8 mm. These eggs were apparently buoyant when alive; they are thus perhaps the largest pelagic eggs known. As yet there is no record that any scientist has ever examined ripe eggs of halibut from American waters.

The earliest known stage of the halibut is that described by Dr. Peterson of the Danish Zoölogical Station. It was procured in Christiansand; it measured 32 mm. (1 3-8 inch). This was still in the free-swimming condition, as was indicated by the position of the left eye, which had only just commenced to move forward and upward; it had 104 rays in the dorsal fin, 88 in its anal, 22 in its caudal; the mouth was large and the gill cover had a row of spines.‡

Young halibut about 12 inches long, 3 3-4 inches across at the widest part, have occasionally been found in the water of shallow bays, like that of St. Andrews; this seems to indicate that after passing their earliest stages in deep water, they seek shallow water for a certain portion, at least, of their adolescent period, and then

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* Marketable Marine Fishes, 1896, 243.

† British Marine Food-Fishes, 1897, 315.

‡ British Marine Food Fishes, 1897, 318. This specimen was first mentioned by Collet in his "Norges Fiske" (Plate XII, Fig. 10).

pass back again to the deep water in their adult condition. In color, the young forms mentioned above are dull olive marbled with darker blotches, and also with reddish spots and touches on the body and fins. In America none of the young stages have been recorded.

Nothing is known of the rate of growth of the halibut. The smallest known specimen from our coast was about five inches long; this was dredged by Prof. Verril in the Strait of Canso.

IV. *Food.* The halibut is, like the cod, a voracious and omnivorous feeder. The most important portion of their diet probably consists of crustaceans like crabs, lobsters, etc., and molluscs, such as clams, muscles, snails, etc. They also feed largely upon fishes, particularly flat-fish and flounders. Young cod, haddock, and cusk, are also very commonly eaten by them. Young halibut feed upon shrimp and young flat-fishes.

V. *Size.* The halibut is among the largest of the bony fishes; it is surpassed in size only by the swordfish, the horse mackerel and tarpon. The male is said to be seldom over fifty pounds in weight, while the average sized female is probably between 100 and 150 pounds. A number of exceptionally large individuals are authentically recorded. In July, 1879, two individuals were taken near Race Point, one of which weighed 359 pounds, the other 401 pounds. Goode states that he has record of ten or twelve taken on the New England coast between 1870 and 1880, each of which weighed between 300 and 400 pounds. Nilsson, the Swedish ichthyologist, mentions a halibut taken on that coast which weighed 720 pounds.

## THE ROUGH DAB.

(*Hippoglossoides platessoides.*)

PLATE II.

I. *Distribution and Habitat.* In its range and distribution this species is much like the halibut. It is found on both coasts of the Atlantic, and from the arctic regions ranges south to Long Island

and the coast of England. It is common in forty fathoms of water off the coast of Iceland. Its habitat is, however, more limited than that of the halibut, since it occurs only in rather deep water; it is rarely taken from water less than twenty fathoms, but on the other hand it does not descend to such great depths, since it is not known to be present beyond eighty fathoms. It is a rather common food fish in northern waters, particularly in England and Scandinavia, though it is never very abundant anywhere. In summer it is found only in deep water, but in winter it approaches nearer the coast. It is not abundant enough in Rhode Island waters to make it of any importance in this locality as a food fish. It has doubtless been taken in winter many times without being discriminated by the fishermen from other species; it is not unusual in deep water off southern Massachusetts and Rhode Island. It is not common at Woods Hole, though it has been taken in winter in shallow water.*

II. *Reproduction.* For practically all our knowledge regarding the habits of this fish we are indebted to European observers. The following account of its eggs and spawning habits is on the authority of McIntosh and Masterman,† and of course refers to observations on the European variety (*limandoides*). In British waters specimens of this species with ripe eggs are found from February to May, and are most numerous in March. On the Scandinavian coast the spawning season is apparently during February and March.

The eggs of this species had been known since 1884, but were not definitely identified until 1895. The egg is buoyant and translucent, and when first extruded from the oviduct measures about 1.2 mm. (1-20 inch). After being in sea water for about twelve hours, a considerable amount of water is taken up inside the outer capsule so that the diameter of the egg increases and becomes about 1.8 mm. (1-14 inch). The eggs hatch in about fourteen days.

III. *Food.* In the tenth Report of the Scottish Board of Fisheries are given the results of examination of the contents of 569 stomachs

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* Proc. U. S. Mus., 1880, 471.
† Smith, Fishes of Woods Hole, Bull. U. S. Fish Com., 1897, 108.

of this species taken from the Firth of the Fourth. The different kinds of marine animals found occurred in the following percentages: crustacea in 44 per cent. (shrimp of various kinds, hermit crabs, swimming crabs); echinoderms in 22 per cent. (sandstars, brittle stars, common starfish); fishes in 14 per cent. (gobies, whitings, young dabs); marine worms in 9 per cent.; molluscs in 6 per cent.*

IV. *Size.* In American waters this fish exceptionally reaches a length of 20 to 24 inches; its weight ranges from 2 to 5 pounds. Dr. Fulton found that off the east coast of Scotland the smallest ripe male was 5 inches long, while the average length of mature males was 6.5. The smallest ripe female was 5 inches long, the largest 16.5 inches, with an average length of 8.8 inches.

## THE SUMMER FLOUNDER.

(*Paralichthys dentatus.*)

PLATE III.

I. *Distribution and Habitat.* This fish is confined to the American coast of the Atlantic, and is more particularly a warm-water fish than most of the common species of the family. It ranges from Cape Cod to Florida, though it is rare south of Charleston. The center of its abundance seems to be in the waters about Rhode Island, Connecticut, and Long Island, where it is taken in very large numbers during the summer.

The fish of this species begin to appear in inshore waters in May and are taken in water from 2 to 20 fathoms in depth until October. They then move out into deeper water for the winter. Unlike the winter flounder, which has a preference for grassy and muddy bottoms, the fishes of this species are apparently more abundant where the bottom is sandy. They are somewhat gregarious in their habits, but like most of the species of this family, they do not possess this tendency in any marked degree. Their movements are probably

* Cunningham, op. cit., 244

adjusted in accordance with seasonal changes of temperature and also with the variations in the abundance of food in particular localities.

II. *Reproduction.* Practically nothing is known of the breeding habits of this species. It has never been found with mature eggs, nor is there any record that anyone has ever seen any of the younger stages. Goode states that the smallest specimens certainly known were eight or nine inches in length. The above considerations seem to indicate the probability that the summer flounder spawns in deep water away from the shores in the winter, and that the young do not enter shallow water until they have reached an advanced stage of development.

III. *Food.* Their food is like that of most of the flat-fishes; it consists of small fishes, crustaceans, molluscs, sand-dollars and squid. Specimens taken from trap usually have such fishes as butter-fish and scup in their stomachs, though these they have probably eaten from necessity on account of the artificial conditions under which they are confiued.

IV. *Size.* The average length is from 16 to 30 inches, and the average weight about 2½ pounds. Exceptionally it reaches a length of 3 feet and a weight of 15 pounds.

## THE FOUR SPOTTED FLOUNDER.

(*Paralichthys oblongus.*)

PLATE IV.

I. *Distribution and Habitat.* The limits of the geographical range of this species have never been very accurately determined. Its distribution is apparently very limited, since it is not recorded south of New York and has been taken only very rarely north of Cape Cod. In 1877 a single specimen was captured at the mouth of Salem harbor by the United States Fish Commission. It is said to be most abundant on the coast of New York and the neighboring

islands. In Rhode Island it is taken somewhat frequently in outside waters, but is only rarely found in Narragansett Bay. May, June, and early July are the only months in the year when it approaches near enough to the shore to be taken in the fish-traps. At Woods Hole, it is stated by Dr. Smith that this species is most abundant in June, particularly about the time of the scup run. Its normal habitat is in somewhat deeper water than that of the preceding species; according to Goode, it is the most abundant in 10 to 20 fathoms of water. Several specimens of this species were taken in 100 fathoms of water off the Rhode Island coast by the *Fish Hawk* in September, 1880.

II. *Reproduction.* The testimony of numerous observers agrees that this species spawns in May. The eggs have been experimentally hatched by the United States Fish Commission at Woods Hole. The eggs are buoyant, 1-26 of an inch in diameter, and they hatch in eight days when the mean water temperature is 51° to 56° F.* The young of this species have very rarely been observed, but in the autumn of 1885 and 1886 large numbers 2 or 3 inches were seined at Woods Hole.

III. *Food.* The food of this fish is much like that of most of the other members of the Flat-Fish family. All bottom animals contribute largely to its diet. The stomach of most specimens examined contained the remains of annelids, molluscs, the smaller crustacea, and small fishes.

IV. *Size.* It seldom attains a length of over 14 inches, and usually weighs about a pound.

## THE RUSTY FLAT-FISH.

(*Limanda ferruginea.*)

PLATE V.

I. *Habitat and Distribution.* This species inhabits the American coast of the Atlantic from Labrador to New York. DeKay reported

* Smith, Fishes of Woods Hole, Bull. U. S. Fish Com., 1897, 108.

this flat-fish to be very rare and occurring only in deep water. It is very common in Vineyard Sound and is observed in water 10 to 12 fathoms deep, where it is present throughout the year. Numbers are often caught, incidentally, while fishing on the bottom for other species. In Great Harbor, Woods Hole, a few are taken in fyke nets in winter. *Specimens have been taken on the Pecten ground, off Watch Hill, Rhode Island.

II. *Reproduction.* Little is definitely known with regard to the reproduction of this fish. Stephen R. Williams, while collecting young flat-fishes at Woods Hole in June, 1898 and 1899, in the course of his investigations on the development of the winter flounder, found two apparently different larval forms of flat-fishes. These were of different sizes; the smaller at the end of the period of the metamorphosis measured 8 to 9 mm.; the larger at the metamorphosis measured 13 to 14 mm., and were more bulky and had somewhat more pigment. These larger, more pigmented, specimens were considered by Williams as possibly the young of the rusty flat-fish (*L. ferruginea*).†

III. *Food.* Examination of the stomach contents of this fish have shown crustacea, molluscs, annelids, and small fishes.

IV. *Size.* The average size is stated to be about 14 inches in length. The specimen described by DeKay was 18 inches long and 8.5 inches broad.

## THE WINTER FLOUNDER.

(*Pseudopleuronectes americanus.*)

PLATE VI.

I. *Habitat and Distribution.* This species has an extensive range along the American coast of the Atlantic; it is abundant from Labrador to Chesapeake Bay. It has a preference for muddy and

* Smith, loc. cit.

† Changes Accompanying the Migration of the Eye in Pseudopleuronectes Americanus. Stephen R. Williams, Bul. Mus. Comp. Zool., Vol. XL, No. 1, 1902, 4.

grassy bottoms. It apparently undergoes no extensive migrations, since it is a permanent resident and is captured through the year. It is much more abundant, however, from October to May than in the summer, when only scattering specimens are taken in the traps. This shows a slight tendency for these fishes to move out from the warm inshore areas during the summer months into the deeper colder waters.

II. *Reproduction.* The spawning season of the winter flounder is from February to April. The eggs are 1-30 inch in diameter; they are very glutinous when first extruded from the body and stick together in large masses and adhere to whatever objects they touch. The eggs are demersal, that is, they sink to the bottom; in this respect they are an exception to the eggs of all the other species of this family. The artificial hatching of the eggs has been carried on very extensively at Woods Hole by the United States Fish Commission. The eggs hatch in 17 or 18 days when the average water temperature is 37° or 38° F. The average number of eggs to a fish is 500,000. On March 6, 1899, 1,462,000 eggs or 30 fluid ounces were taken from a fish that weighed 3½ pounds after spawning. The spawning fish are very abundant and are captured in fyke nets on hard clay bottom in water 6 to 15 feet deep.*

III. *Food.* The winter flounder feeds mostly on the small invertebrates of muddy bottoms. As the mouth of this species is smaller than that of most of the flat-fishes, its diet is more limited and other fishes form a less important portion of its food. It feeds largely on crabs, small shells, shrimp, squids, and annelids.

IV. *Size.* Its usual length is from 12 to 15 inches. The average weight of specimens taken in shallow water is something over a pound, while fishes taken further out in deeper water are larger and average about two pounds.

Young specimens are very frequent in inshore waters, and are often taken in the seine on sandy shores. At the Experiment Station of

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* Smith, loc. cit.

the Rhode Island Fish Commission at Wickford young specimens of this species are often found in the hatching boxes during the latter part of May. Williams,* at Woods Hole, succeeded in getting quantities of young in larval stages at and about the time of metamorphosis. These were present all through the month of June, though by the 20th of the month all of this species had metamorphosed. He obtained these specimens by towing with a coarse scrim tow-net near the wall of the "outer basin" of the United States Fish Commission wharf during the rising tide. "They are most abundant on clear days when the wind is on shore and the tide comes in from the east. On very calm or rough days they are not plentiful. My most successful skimmings were made early in June, and twice I obtained as many as one hundred young fish during the inward flow of the current (three to four hours)." Williams states that the young reach a length of 75 mm. (3 inches) by the end of August, when they were about seven months old. This statement apparently refers to specimens kept under artificial conditions.

V. *Color Variations.* This species is remarkably subject to apparently abnormal color variations. Doctor Mitchell described two color varieties of the winter flounder. "One of these had a yellow margin on the lower side, surrounding the white of that side. This border was three-quarters of an inch wide and in striking contrast with the pearl of the contiguous parts within it and the brown of the adjacent fins. The other variety, obtained April 9th, 1815, has a whiteness of the upper side and nearly as clear as that of the nether surface over rather more than half its extent. The anterior part is blanched in this manner."† The dorsal, anal, and ventral fins were lighter than is usually the case, and their rays were tinctured with yellow.

DeKay mentions a specimen obtained in April which he describes as "not only reversed but doubled." "Its color on both sides was uniform bronze with a white patch on its right side near the chin,

* Williams, loc. cit.

* Quoted from Dr. T. H. Bean, Fishes of N. Y. Bull. N. Y. State Mus., 60, 1903, 729.

almost entirely denuded of scales; it had a singular protuberance over the eye, noticed by Dr. Mitchell in his *melanogaster*.*"

A dark-bellied variety appeared in Greenwich Bay, R. I., in 1897. They had first appeared some year's before that, but in that year attained their maximum abundance, which was estimated to amount to 33 per cent. of the whole number of flat-fish. The numbers of this colored variety gradually declined so that in 1900 they were estimated at 4 per cent., and they have since almost entirely disappeared.†

## SAND-DAB.

(*Lophopsetta maculata.*)

PLATE VII.

I. *Habitat and Distribution.* This species ranges from Casco Bay to South Carolina. It is abundant everywhere in shallow water, particularly on sandy bottoms. It is present in Rhode Island waters throughout the year. This fish reaches a length of ten or twelve inches, and is very abundant and its flesh of good flavor, yet it is of no commercial importance because, on account of its extreme thinness, the amount of its flesh is so small that it is of little use as food. It is in fact so thin that it is quite translucent, which fact is the source of one of its common names "The Window Pane."

II. *Reproduction.* The sand-dab spawns in the early part of June. The eggs are buoyant, non-adhesive, 1-24 of an inch in diameter, and hatch in eight days when the average temperature is 51° to 56° F. According to Dr. Smith, there is a large run of these fishes at Woods Hole in June during the spawning period.

III. *Food.* The food of this species seems to consist chiefly of small fish, and the smaller bottom invertebrates like small crabs and annelids.

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* Quoted from DeKay, N. Y. Fauna, Fishes, 1842, 296, Pl. 49, Fig. 158.
† Bull. U S. Fish Comm., 19, 1899, 305.
Report of R I. Fish Comm., 31, 1900, 19.

IV. *Size.* The average length of the adult sand-dab is about 11 inches; they probably seldom attain the weight of a pound. Young specimens are rather common in shallow water with a sandy bottom. Williams,* 1898 and 1899, found many larval specimens at Woods Hole closely associated with the young of the winter flounder. Some of these specimens he kept for some time in artificial enclosures and observed their growth. They grew very rapidly, much more so than the flounders. One which measured 10 mm. (2-5) inch in length and 5 mm. (1-5 inch) in depth during eleven days grew to 22 mm. (9-10 inch) in length and 12 mm. (½ inch) in depth. Specimens 2 and 3 inches long are often taken in the seine along sandy beaches after the middle of July.

## THE AMERICAN SOLE.

(*Achirus fasciatus.*)

PLATE VIII, AND IX.

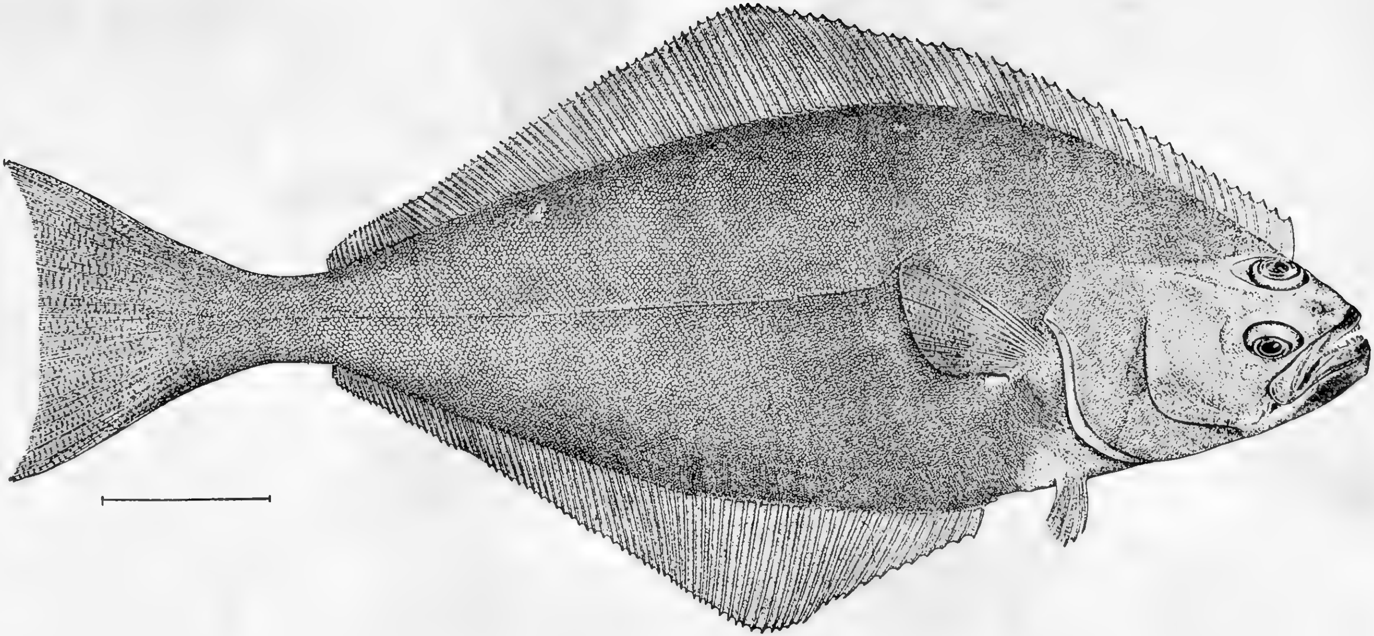
I. *Habitat and Distribution.* This species is the only common representative of the Sole family on the American side of the Atlantic. It is found along the Atlantic and Gulf coasts from Cape Ann to Brazos, San Diego. It is common in shallow water at the mouths of rivers with sandy bottoms, and often ascends rivers for considerable distances above tide water. They are somewhat rare in Narragansett Bay, but a few are taken in the traps each year. It seems to be more commonly present during summer and early fall; Dr. Smith states that at Woods Hole it is present the year round. Nothing is known of its breeding habits. On account of its small size it is of no commercial importance, though its flesh is said to be of good flavor.

The sole of European fame is not found in American waters. Two or three attempts have been made by United States Fish Commission to introduce it from English waters, but apparently without success.

* Williams, loc. cit.

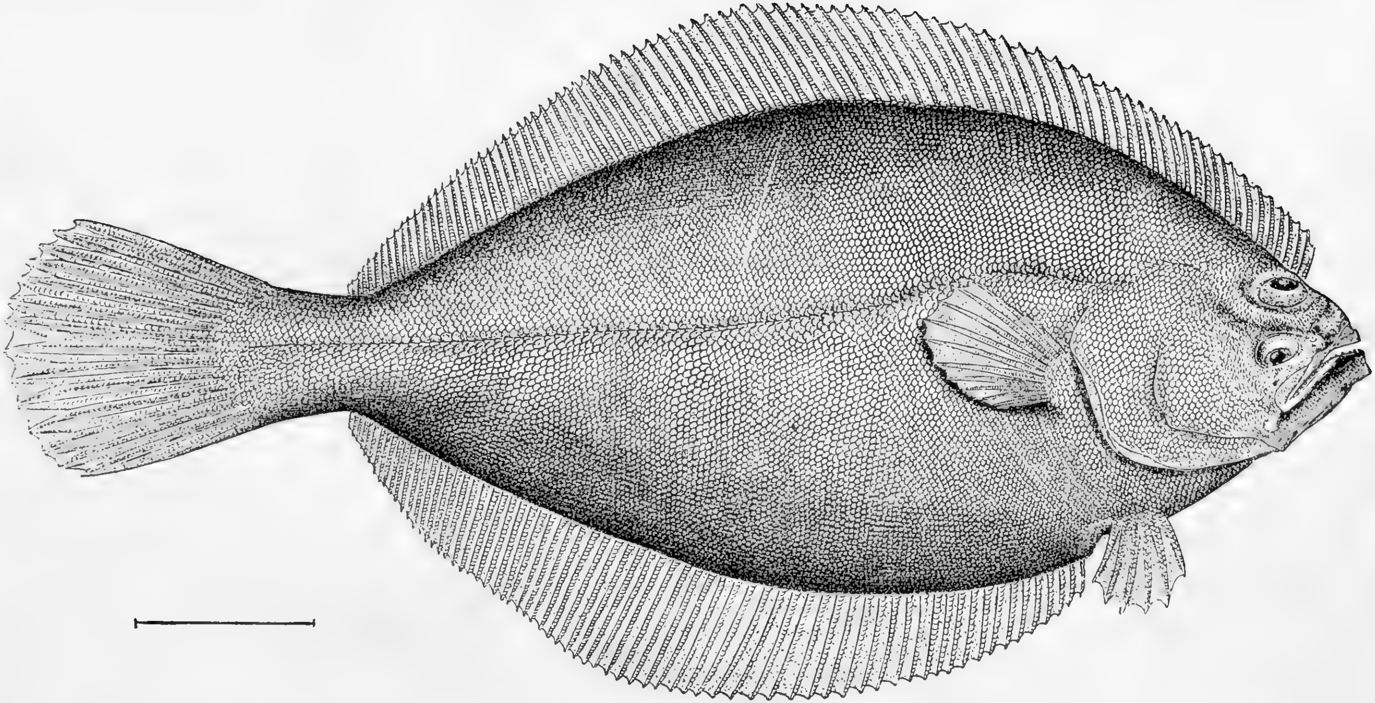
II. *Food.* Few observations have been made of the character of the food of this species. It seems to be a vegetarian, to a great extent at least, if not exclusively, since Dr. Linton, in 1899, examined eight specimens and found in their stomachs only vegetable debris, which appeared to consist mostly of *Fucus* and eel-grass.

III. *Size.* This is the smallest of American flat-fishes. It seldom exceeds five or six inches in length.



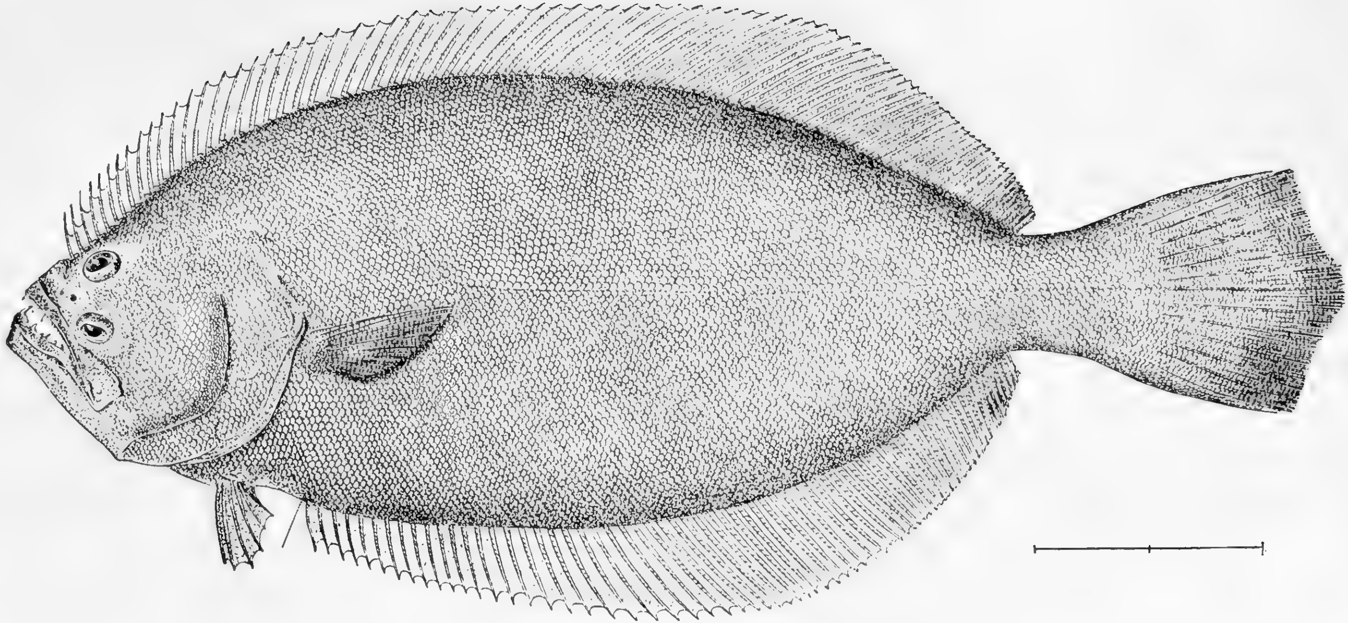
The Halibut.
(Hippoglossus hippoglossus).

Plate I.



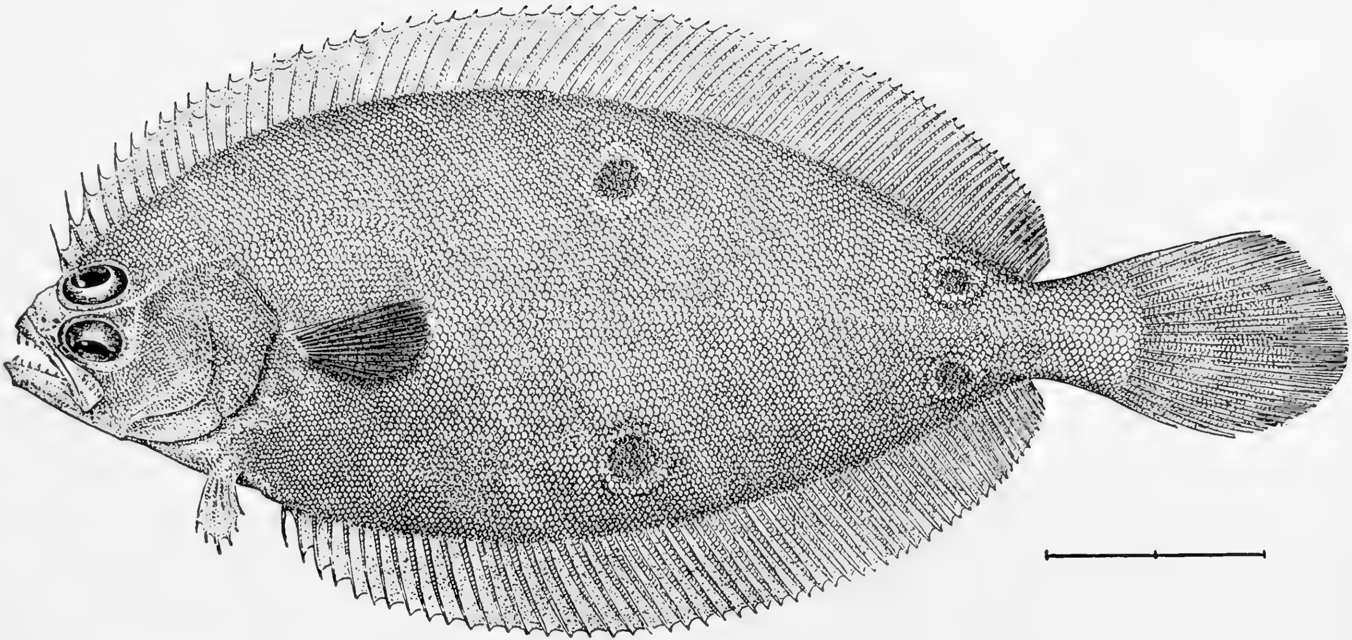
The Rough Dab.
(Hippoglossoides platessoides).

Plate II.



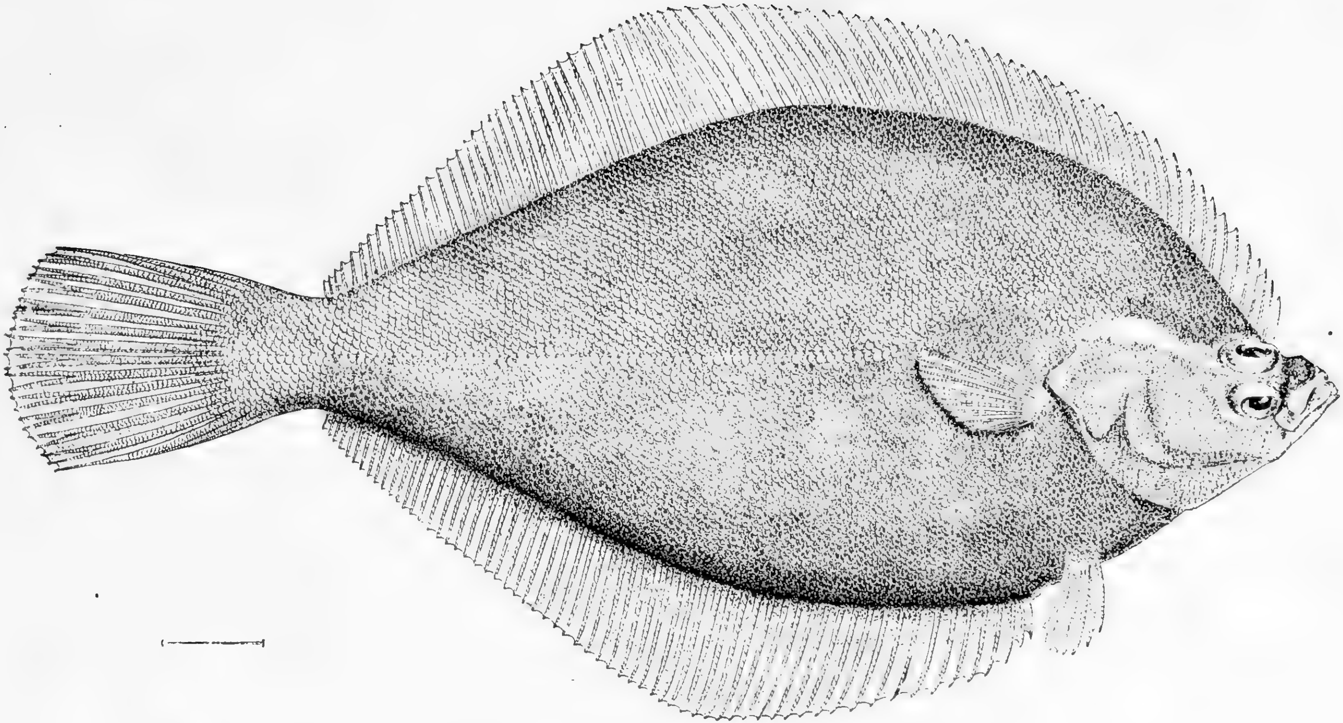
The Summer Flounder.
(Paralichthys dentatus).

**Plate III.**



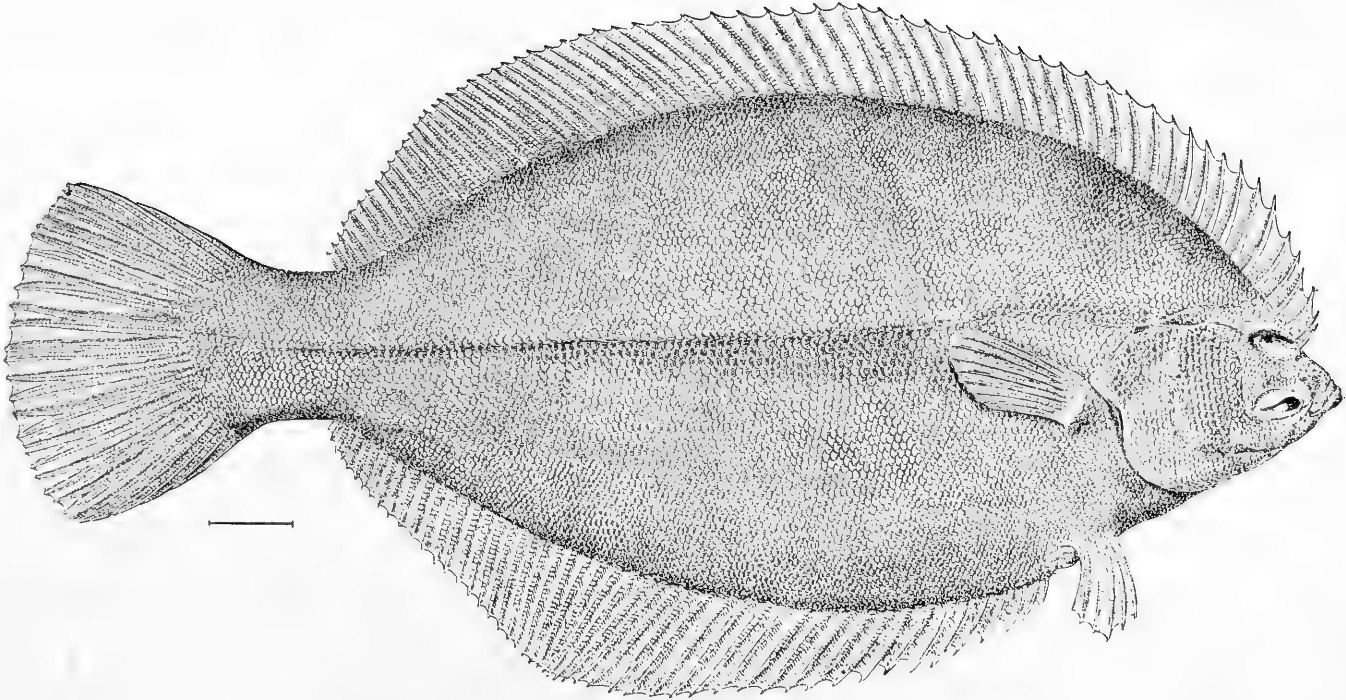
THE FOUR SPOTTED FLOUNDER.
(Paralichthys oblongus).

PLATE IV.



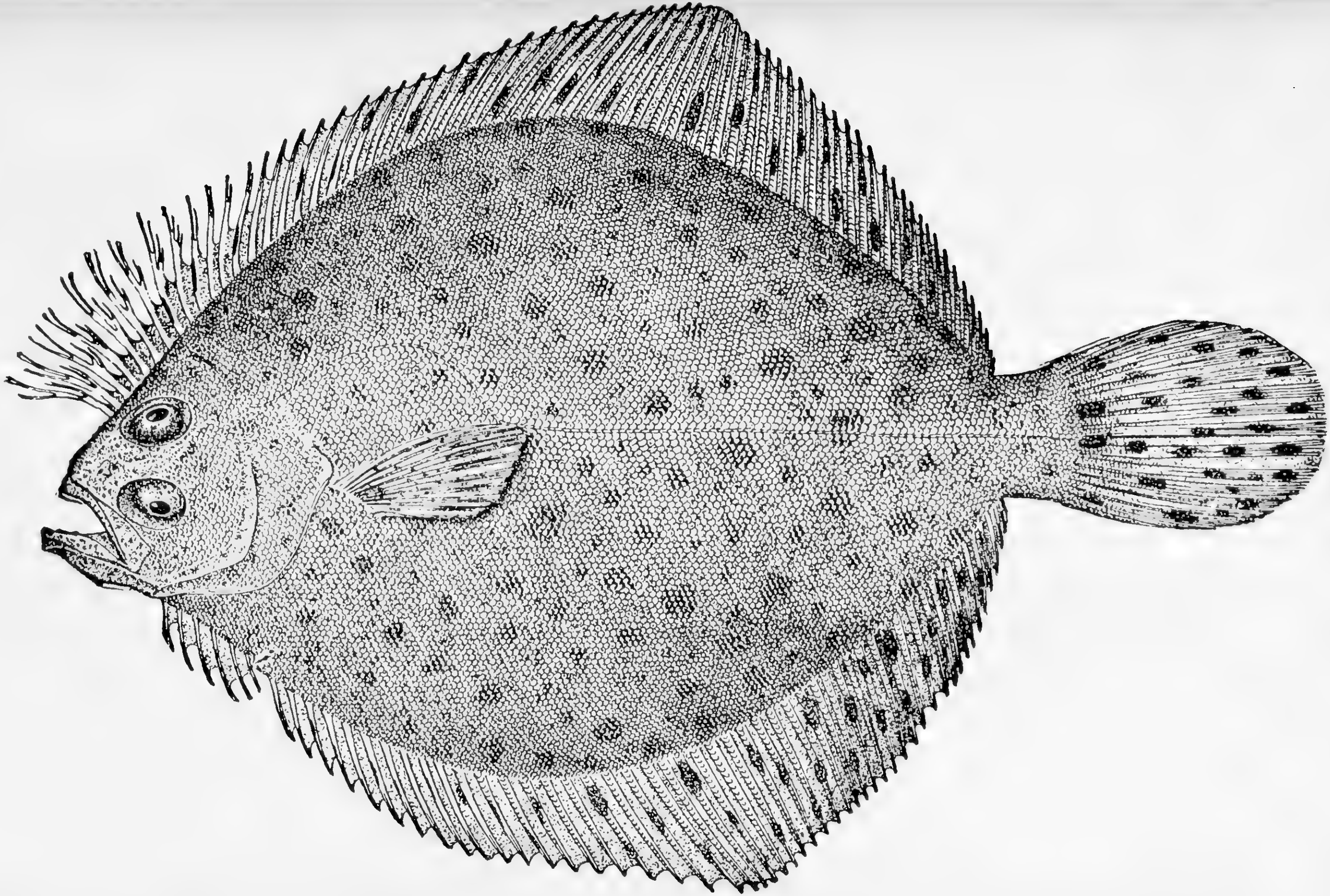
The Rusty Flat-fish.
(Limanda ferruginea).

Plate V.

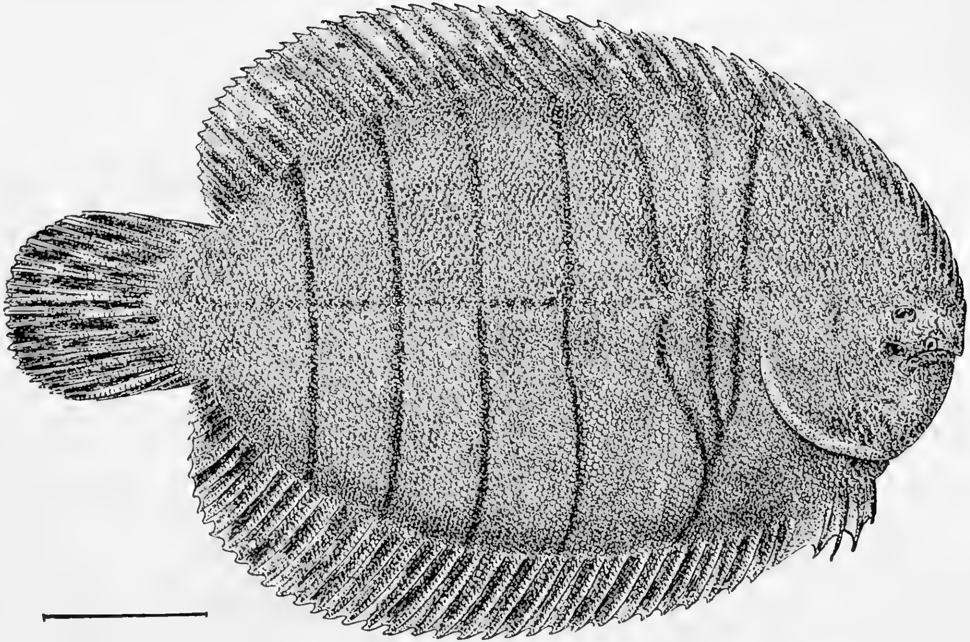


The Winter Flounder.
(Pseudopleuronectes americanus.)

Plate VI.

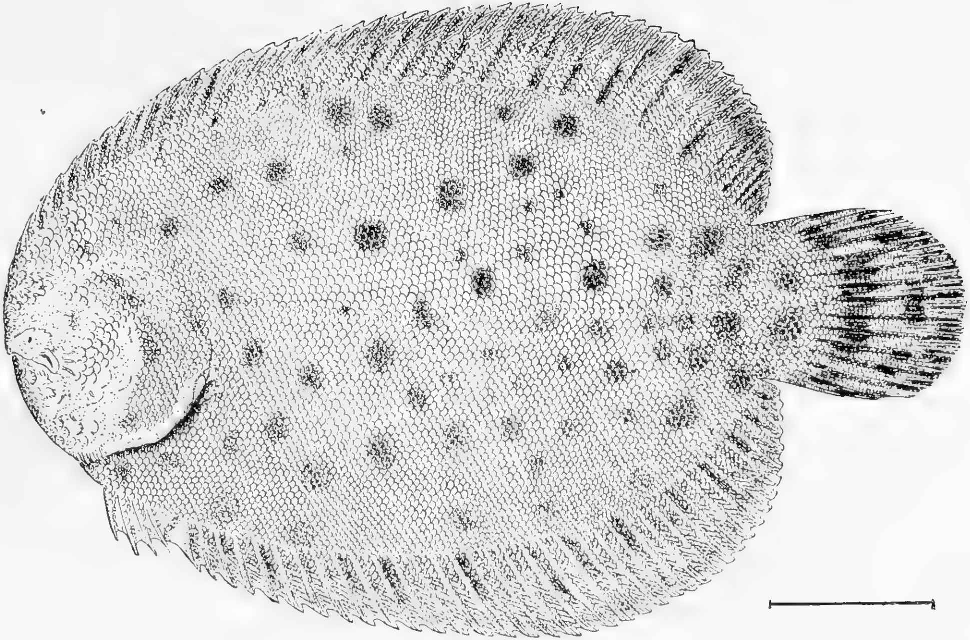


THE SAND DAB.
(Lophopsetta maculata).
PLATE VII.



THE AMERICAN SOLE.
(Achirus fasciatus.)
Upper side.

PLATE VIII.



THE AMERICAN SOLE.
(Achirus fasciatus)
Under Side.
PLATE IX.

# THE FISHES OF RHODE ISLAND.

## VI. A DESCRIPTION OF TWO YOUNG SPECIMENS OF SQUETEAGUE (CYNOSCION REGALIS) WITH NOTES ON THE RATE OF THEIR GROWTH.

(WITH TWO FIGURES.)

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The identification of the eggs and of the larval and adolescent stages of any species of fish is a necessary preliminary to the investigation of its life history. Without the means of determining the species to which eggs and young belong, it is of course impossible to obtain evidence regarding the times and places of spawning, the habits of the young, the conditions which influence their lives, their migrations, etc. Any addition, therefore, to our at present somewhat meager knowledge of the younger stages of the marine fishes is of value. This present paper is intended to present a few notes regarding the rate of growth of young squeteague (*Cynoscion regalis*) and to describe two specimens smaller than any of that species yet described.

The only systematic attempt that has been made to investigate the life history of the squeteague was that of Eigenmann (1901), which was undertaken at the request of the United States Fish Commission. He was able to ascertain many important facts regarding the young of this species, though the very earliest stages were not obtained by him. The smallest specimen that he secured

was taken at the head of Narragansett Bay and was 25 mm. (1 inch) in length as measured to the base of the caudal fin. The smallest specimen which he figured in his report* was 32 mm. (1.3 inches).

The two specimens referred to in this paper were taken in Mill Cove, Wickford harbor, at the Experiment Station of the Rhode Island Commission of Inland Fisheries; they were found in the canvas bags which are used in the rearing of the young lobster fry. One of these young squeteague measures 12.5 mm. ($\frac{1}{2}$ inch) in length to the base of the caudal fin; the greatest depth of the body was 3.75 mm. (.15 inch), which is 30 per cent. of the length; the eye was about 1.2 mm. The other specimen was 6.5 mm. (.25 inch) in length, and 2 mm. (.08 inch) in depth, which was a little over 30 per cent. of the length; the eye was .7mm. in diameter. These measurements were made after the specimens had been killed (one according to Worcester's formula, the other in Zenker's fluid) and preserved in 80 per cent. alcohol, so that a very slight shrinkage may have taken place. Along with these there were also taken about a dozen others which ranged in size between the two mentioned above, and which were apparently of the same species. Several of these were kept in small cars until as late as October, during which time they become large enough to make certain the identification of these fishes as young squeteague.

The rearing bags used by the Rhode Island Fish Commission are made of heavy canvas and are 10 feet square and 4 feet deep. Circulation of water in them is maintained by a constantly revolving paddle which draws the water in at the bottom of the bag through a window of wire screen and drives it out through similar windows placed at two opposite sides.† These screens are made of copper wire-netting of 20 meshes to the inch. These young squeteague, then, could only have gotten into the bag by being drawn up through the bottom screen when they were still small enough to pass through

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* Bull. U. S. Fish Commission, XXI, 1901, 45.

† For further details regarding the rearing plant and the construction of the canvas bags, see Report of the R. I. Fish Commission, 36, 1905, 120.

the meshes. This could only have been when they were less than perhaps slightly over 1 mm. in their greatest diameter, which probably corresponds to a length of perhaps about 3.5 mm. or 4 mm. It is therefore possible to get an approximate idea of the rate of growth of squeteague of this age.

These specimens were taken from the same bag on July 28; this bag was put into the water on July 11; the largest specimen, therefore, could not have been in the bag more than 17 days, and in that time or less it must have grown to 12.5 mm. from about 4 mm. or less. The conditions of life existing in these bags in which the lobster fry are so successfully reared apparently do not differ materially from those in the water outside, except that an abundant food supply is always present; nevertheless the conditions in these bags must be somewhat artificial, and how much these affect the rate of growth of the young squeteague is, at the present time, impossible to decide.

The finding of such small fry of the squeteague under such circumstances would ordinarily justify us in drawing further conclusions regarding the time and place of the spawning of this species. But unfortunately it is not possible to do so with certainty in this case. The writer of these notes, on July 3, at 9 A. M., fertilized artificially several thousand eggs of squeteague which were secured from fish traps out in Narragansett Bay. These hatched out about 1 A. M., July 5, and were released at the Experiment Station in the water of Mill Cove at 4 P. M. of the same day. It is thus impossible to know whether the specimens found on July 28 came of the lot released on July 5, or whether they came from eggs of squeteague which spawned naturally in the cove. It is evident, however, that the water of the cove is very favorable to the eggs, since they hatch with such facility there; the water there seems, also, to be well adapted for the younger stages of the fish, since they were present in the cove until after the middle of August at least, and those specimens which were kept in captivity thrived until killed by the cold weather in October. There is, therefore, in the present observations, nothing which does not tend

to support the generally accepted opinion that the squeteague spawns in inlets, sheltered coves, at the mouths of rivers, and in similar places.

The spawning time of the squeteague is usually considered to be about June 1; this opinion is based on the fact that some of the squeteague which come in at that time have ripe roes. This season (1907), however, owing to an exceptionally late spring, all marine life was much retarded in its seasonal development, and no squeteague with ripe roes were seen by the writer until after June 20, while they seemed to appear in the greatest numbers about the first of July. Therefore, if the specimens taken at the Experiment Station came from eggs which were spawned naturally in the cove, they could hardly be much over 40 days old and were probably less than 30 days old, since the chances are that they would have been hatched from eggs spawned at the time when spawning squeteague were present in the greatest numbers, which, in Narragansett Bay, seems, this year, to have been during the first week of July. The spawning in the coves would probably have taken place after, rather than before, the mature fishes appeared in the water of the bay outside. It will not be far from the truth, then, if the age of these young squeteague found in the cove be placed at between 20 and 30 days, and perhaps nearer the former time than the latter.

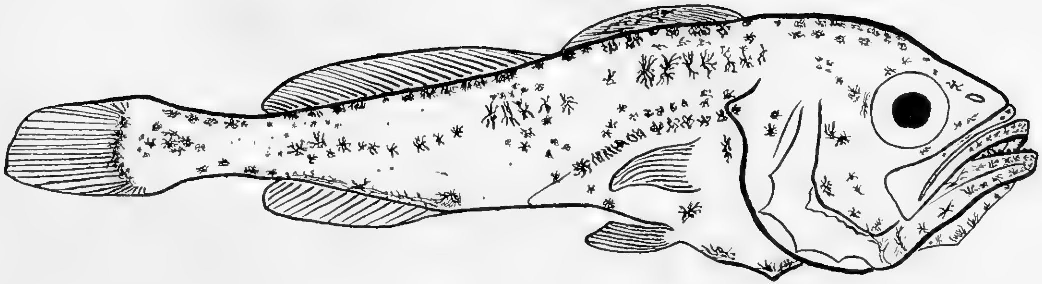
Two other specimens were later taken from the rearing bags, on the following dates: Specimen 25 mm. in length, found on August 8, in a bag which had been in the water for 12 days; specimen 29 mm. in length, taken on August 13, in a bag which had been in the water for 15 days. This latter specimen indicates an increase in length from about 4 mm., or less, up to 29 mm. during a period of not more than 15 days, and of course it may have been a somewhat less time.

The following are the sizes of squeteague taken by Eigenmann, and the dates and places of their capture:

Specimen 32mm. long, taken at Indian Point, July 5, 1900.
Specimen 41mm. long, taken at Indian Point, on the same date.
Specimen 70mm. long, taken at Indian Point, on the same date.

Young Squeteague.
(Cynoscion regalis).
6.5 mm. long. x20.

Plate X.



Young Sqeteague.
(Cynoscion regalis).
12.5 mm. x10.

Plate XI.

Specimen 95mm. long, taken at Wareham, August 9, 1900.
Specimen 120mm. long, taken at Wareham, August 22, 1900.
Specimen 200mm. long, taken at Vineyard Sound, September 7, 1900.

Several young squeteague from 80 to 100 mm. long were taken by the United States Fish Commission in Hadley harbor, near Woods Hole, on September 9, 1893. In all these cases, the spawning season was probably from two to five weeks earlier than in 1907.

Drawings of the two specimens taken on July 28 are shown in Plates X and XI. These are in outline and aim to show only such external characters as the form of the fins, mouth parts, gill covers, pigmentation, etc., which will make possible the future identification of young squeteague of these sizes.

In form and proportions these two specimens differ considerably from the adult and from the stages described by Eigenmann. The head and the eye are very large relatively, as is usually the case with the very young of fishes. The contour of the tail also differs, but the details of its development must be left until fresh specimens are available.

The specimen 6.5 mm. long is shown in Plate X, where it is magnified to twenty times the natural size. The greatest body depth is along a line drawn vertically a little behind the posterior margin of the eye. The embryonic fin-fold has not disappeared, though the spines of the unpaired fins are all well differentiated. The head is rounded in profile and the conical snout of the later stages is not yet developed. Teeth are present on the lower jaw. The bones of the gill-cover are only partially developed, so that at least five branchiostegals are visible from the side of the fish.

The pigmentation of the young squeteague is characteristic. This has been adequately described for the later stages by Eigenmann, but there are noticeable differences in these early stages. Reference to the plate shows the most important features of the arrangement of the color spots. Along the lateral line is a row of about eight rather large chromatophores aggregated into two groups, one of which is in that area of the skin between the anal fin and the posterior

end of the dorsal fin, and the other is below the anterior end of the soft dorsal. Each group has a few smaller chromatophores above and below it. The group under the posterior end of the dorsal fin was probably the first to appear. In this specimen, as shown in the plate, there was an enormous chromatophore in the skin just above the anal fin; this was apparently connected by processes with the color cells of the lateral line group just above it, and is probably the origin of the network of chromatophores which are found in a similar position in the later stages. These groups of pigment cells, when the young fish is looked at with the naked eye, have the effect of producing the appearance of two grayish or dusky bands on the sides, the anterior one of which is just beginning to appear and is much less pronounced than the posterior one. Other large expanded pigment spots are found in other places. The most conspicuous of these are scattered around the head region, particularly on the under side; a small clump is also found on the back near the beginning of the dorsal fin; two or three chromatophores are found along near the ventral edge of the caudal peduncle, while only one or two have yet appeared at the base of the caudal fin. The tissues of the fish are so transparent that the dense pigmentation of the posterior part of the body cavity is visible from the outside.

Plate XI shows the drawing of the specimen 12.5 mm. in length. It is here enlarged to ten times the natural size. The greatest body depth lies along a line drawn not far forward of the posterior margin of the gill-cover. Thus it is evident that the line of greatest body depth has shifted backward appreciably from the position which it occupied in the previous stage. The fins are fully differentiated and the embryonic fin-fold has completely disappeared. The snout has become somewhat pointed, though not so much so as in the later stages. The mouth has become more oblique; the maxillary and premaxillary have grown broader; the teeth of the lower jaw are large, strong, incurved, particularly along the sides; the teeth of the upper jaw are numerous but very minute; the opercular bones have grown downward and backward so that the branchiostegals are

carried down ventrally in such a way as to be scarcely visible from the side.

In the pigmentation this stage differs considerable from the one just described. Chromatophores are present in greater numbers on every part of the fish. Those on the lateral line have increased in numbers so as to extend along nearly its whole length, and two new groups have been added, one just under the spinous dorsal, the other just in front of the base of the caudal fin. Thus to the naked eye the fish of this stage looks darker than one of the preceding, and the dusky bands on the side have increased to four. A row of branched, anastomosing chromatophores runs vertically along the base of the caudal fin-rays. A similar row of network-like chromatophores lies all along the base of the anal fin. Two or three rows of very compact chromatophores run along the back parallel to the insertion of the dorsal fin; three or four short lines of color cells run longitudinally on the top of the head. Two or three branched, somewhat tenuous pigment cells lie in the fin-membrance of the spinous dorsal. Scattered chromatophores occur along the gill-covers, on the upper and lower jaws, and on various other parts of the body.

## DISTRIBUTION OF CLAM SETS IN 1907.

The subject of the growth, habits, and artificial culture of the soft-shell clam (*Mya arenaria*), and the interesting facts of the peculiar distribution of the "set" along the shores of Narragansett Bay, has been fully discussed in the earlier reports of this Commission.

Occasionally, in a certain year, a remarkably thick set has occurred upon one or more limited portions of the shore, while in other years the set is equally thick in other, but usually not in the same localities. In some years none of the portions of the shore examined has a set even remotely approaching in abundance those referred to.

In 1898 the station of the Commission was located at the Kickemuit river, and the study of the life history of the clam was undertaken by Professor Kellogg, now of Williams College, who found considerable numbers of clams, though no systematic search was made for thick clam sets along the shore. In 1899 the station was located at Wickford, and for the first time the phenomenon of an exceeding thick set of clams of about a month in age and 1-32 to ¼ inch in length was discovered about the 4th of July, and described. This was found on the southwest point of Cornelius Island; 12,500 clams were counted from one square yard.

In 1900, on the same shore but in a slightly different locality, the same phenomenon occurred; 7,715 clams were counted from one square yard. In that year the set was also thick at Old Buttonwoods.

In 1901 a most extraordinary set was found on the east shore of Green's Island, north of Conimicut.

In 1902 there were no places discovered where the set was at all comparable in thickness with any of those just mentioned.

In 1903 a phenomenal set was again found on the same shore of Cornelius Island, but nowhere else in the bay.

In 1904 the same phenomenon recurred on Cornelius, and surpassed any of the previous sets excepting, perhaps, that of 1901 at Green's Island.

Since 1904 no such sets have been found anywhere. The explanation of this peculiarity of yearly distribution is not apparent.

In the hope of ultimately throwing some light upon it, the examination of the shore in search of the new set is being made each season, and a record kept of the conditions.

The following gives, in tabulated form, the conditions in twenty-four localities during the past four years:

*Condition of Clam Grounds Visited in November and December,* 1907 (*also January,* 1908), *with Abundance of Clam Set in* 1904, 1905, *and* 1906.

| Locality. | The Abundance of Clam Set in. | | | |
|---|---|---|---|---|
| | 1904. | 1905. | 1906. | 1907. |
| 1 Academy Cove, Wickford | Extremely thick | Scant | Scant | Scant. |
| 2 Bullock's Point | Very good | None | Scant | Scant. |
| 3 Buttonwood's Shore | Poor | | | Fair |
| 4 Conanicut (west) | Good | Few | Scant | Scant |
| 5 Cold Spring Beach | Fair | Few | Scant | Scant. |
| 6 Cornelius Island (S. W. Pt.) | Extremely thick | Few | Scant | Few. |
| 7 Cornelius Island (elsewhere) | Thick | None | Few | Scant. |
| 8 Duck Cove | Good | Few | Few | Few. |
| 9 Fishing Cove | Good | Scattering | Few | Few. |
| 10 Greene's Island (east shore) | None | None | Good | Few. |
| 11 Kickemuit River (west bend) | Very good | Scattering | Few | Fair. |
| 12 Kickemuit River (elsewhere) | Meagre | Scattering | Fair | Few. |
| 13 Mill Cove, Wickford (west shore) | Fair | Scattering | Scant | None. |
| 14 Mill Cove, Wickford (south shore) | Very good | Few | Scant | None. |
| 15 Mill Cove, Wickford (north shore) | Good | Few | Few | Few. |
| 16 Poplar Point | Good | Few | Few | None. |
| 17 Prudence Island | | None | None | None. |
| 18 Prudence Island (west shore) | | None | None | Few. |
| 19 Quonset Point to Greenwich Bay | Good | None | Few | Scattering. |
| 20 Sakonnet River (upper east shore) | | Few | Few | None. |
| 21 Sauga Point | Good | Few | Scant | Scant. |
| 22 Sheep Pen Cove | Good | Few | Few | Few. |
| 23 Vial's Creek | Good | | Few | Scattering. |
| 24 Village Cove, Wickford | Good | | Fair | Fair. |

## LOBSTER CULTURE AT WICKFORD, R. I., IN 1907.

The lobster rearing season began on the 30th of May. From this date the machinery was kept in motion for 75 days, the season finally ending on the 12th of August. The weather conditions throughout the season were quite favorable. The temperature of the water continued cold in the early part of the summer, and at the close of this cold period the sudden ripening of the eggs somewhat

overcrowded the capacity of the plant and results were not as good as might have been obtained from the large number of egg lobsters received. Two hundred ninety-four thousand eight hundred ninety-six lobsters were reared to the fourth stage, as opposed to 189,894 of the preceding year. These lobsterlings were liberated in various places along the shores of Narragansett Bay, as is shown in table at the close of this article.

Constructive work, as well as lack of space, prevented an extensive attempt at rearing to the fifth stage. However, a number of fourth's were kept in the new rearing boxes till quite far along in the fifth stage, and some had reached the sixth stage. In all, 4,900 were reared to these stages.

Some important additions and improvements which were made this season are as follows:

*New Rearing Floats.*—Two additional floats, the same size as the two already on hand, were built. These were placed one on each side of the original floats and connected to them as rigidly as possible by bolting them together in several places with heavy beams which passed from one to the other. In this way the power could be transmitted by ordinary shaft and gear connections, without need of universal joints and sliding sleeves. These floats were not fully equipped till the season was drawing to a close. Nevertheless, one was filled with bags, and the gearing on both was run long enough to test the general scheme. This addition increases the size of the plant from 12 pools to 24 pools, and is also of value in showing the possibility of greatly increasing the size of the plant by adding extra floats and shafting. As the floats are now connected there is a drive of over 350 feet of shafting, not including the short pieces that run down to the paddles. One-inch shafting is used throughout, except in the short drive-shaft on the houseboat, where it is 1 3-16 inches. The slow speed and the limberness of the one-inch shaft prevent any harm from the constant bending of the long floats.

*A New Engine.*—The importance of an uninterrupted current in the bags can not be too strongly emphasized, as has been stated

many times in the reports. An assurance of motor power is therefore imperative, and when a station is situated at some distance from repair shops extraordinary precautions are necessary to prevent breakdowns. A quite complete set of tools and duplicate pieces of those parts of the engine and gearing most apt to give out has been the only precaution taken at the station till last year. On increasing the plant it was decided to put in an auxiliary engine which could be started up at a moment's notice and run independently or together with the other engine. The experience of the summer proved the wisdom of the action. In selecting an engine one of the same make and type as the one already in use was set up, and consequently only one set of fittings was necessary.

*Wooden Boxes Replace Canvas Bags.*—The experiment was tried, last season, of using wooden boxes for rearing purposes instead of the canvas bags. The 14 to 26 days at a time that a bag has to be suspended in the water damages the canvas, and very often, with the utmost care, it is apt to be torn. A great deal of time and labor has been necessarily expended in properly washing and drying the bags in order to prevent the canvas from rotting, and also in patching the holes and weak places. In spite of this care numbers of lobster fry have been lost, occasionally, through holes occurring in the bags, and for this reason many experiments with counted lots have had to be made over. It was for the purpose of preventing such losses that a wooden car was devised. The boxes were made of the same size and general shape of the canvas bags, but certain adjustments had to be made. Most kinds of wood, particularly when new, seem to poison the fry. To overcome this difficulty well seasoned spruce was used and painted inside and out. This painting, together with the continual current of water circulating through the boxes, kept the water pure, and no effect from the poisoning of the wood was noticed. All the corners and angles of the boxes were truncated by fitting wide boards into them. This gave a more even circulation of the water, prevented eddies, and left less chance of the lobsters being thrown against the sides of the box. While the use of boxes is

not entirely past the experimental stage, we have had sufficient success to warrant building cars to replace all the canvas bags. Last summer six cars were used with good results. The proportion of lobsters carried through to the fourth stage in the boxes was determined in case of one counted lot of 20,000 fry: forty-two per cent. arrived at the fourth or "bottom" stage.

One very favorable feature of the box scheme is that the old lobsters bearing mature eggs can be put into the box and allowed to crawl about on the bottom. The fry, when hatched, rise in the water and are kept in motion by the current created by the revolution of the paddles.

*Liberation of Fourth and Fifth Stage Lobsters*, 1907.

| Locality. | Number. | | Character of shore. |
|---|---|---|---|
| | Fourth Stage. | Fifth Stage. | |
| East Poplar Point | 30,000 | 2,500 | Rocky. |
| Mill Cove No. 1 | 3,000 | ........ | Rocky. |
| Rocky Point | 40,000 | ........ | Rocky. |
| Mill Cove No. 2 | 2,000 | 1,000 | Muddy. |
| Portsmouth | 25, 00 | ........ | Stony. |
| Kickemuit River | 45,000 | ........ | Stony. |
| Conanicut Island | 54,000 | ........ | Rocky ledge. |
| Hope Island | 75,000 | ........ | Stony. |
| White Rocks | 5,000 | ........ | Rocky ledge. |
| Total liberated | 279,000 | 3,500 | ........... |
| Used for experiments, etc | 5,896 | 1,400 | ........... |
| Used in rearing to fifth stage | 10,000 | ........ | ........... |
| Total counted out | 294,896 | 4,900 | ........... |

*Total Number of Lobsters Reared each Year since* 1900.

| Year. | Fourth Stage. | Fifth Stage. |
|---|---|---|
| 1900 | 3,425 | ........ |
| 1901 | 8,974 | ........ |
| 1902 | 27,300 | ........ |
| 1903 | 13,500 | ........ |
| 1904 | 50,597 | ........ |
| 1905 | 103,572 | ....... |
| 1906 | 189,384 | 24,800 |
| 1907 | 294,896 | 4,900 |
| Total | 691,648 | 29,700 |

# THE PROBLEM OF FEEDING IN ARTIFICIAL LOBSTER CULTURE.

BY VICTOR E. EMMEL, PH.D.

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## THE PROBLEM OF FEEDING METHODS IN LOBSTER CULTURE.

The problem of obtaining a satisfactory food for the lobster fry is one of fundamental significance in the practical success of lobster culture. The importance of this subject was early recognized by Dr. H. C. Bumpus, who expressed himself in a report on experiments in rearing young lobsters, as feeling "convinced that the food is the determining factor in the problem of brooding."*

Previous to 1898 lobster culture, as conducted by the United States Fish Commission, consisted in merely hatching the lobsters and immediately liberating them in the sea. It became gradually recognized, however, that the immediate liberation of the lobster fry is objectionable because no protection is given the young lobster at the most critical period of its life, for it was soon seen that the period at which the young lobster needs most protection is during the first fifteen or twenty days after hatching. In view of this fact, a series of systematic experiments on rearing lobsters was begun at Woods Hole in 1898, under the direction of Dr. H. C. Bumpus, at that time director of the scientific work of the United States Fish Commission. In 1900 these experiments were transferred from Woods Hole to the Experiment Station of the Rhode Island Fish Commission, where they were continued by Dr. A. D. Mead. Under Dr. Mead's direction these experiments were carried to a successful conclusion. He demonstrated that it is practical to rear the lobster through the first four stages of its life. This work placed the methods of lobster culture on a fundamentally new basis.

In the transition to these new methods of lobster culture it became necessary to make an extensive study of the various factors in-

* 30th Annual Report of the Rhode Island Commission of Inland Fisheries, 1900, p. 44.

fluencing the lobster's life and growth. Obviously food is one of the most important of these factors. A food to be most satisfactory must combine a maximum of results with a minimum cost. The present paper presents the experiments made for the purpose of finding a food most satisfactory for rearing young lobsters.

## I. Previous Feeding-Experiments.

The problem of food necessarily demanded a good share of attention in attempting to rear the lobsters. The item of food is especially important because the rapidly growing lobster requires almost constant feeding, and if not amply fed, their cannibalistic habits lead to mutual destruction. A brief review of the various expedients employed to feed the fry embraces an interesting phase in the history of lobster culture.

### *a. Codfish and Lobster's Liver.*

One of the first foods to be tried was shredded codfish. This was described in a commission report for 1899 as "containing a sufficient amount of air to cause it to descend slowly through the water and thus becomes an attractive object to the young animals, which quickly follow any moving object" (p. 98).

Codfish was soon replaced by lobster's liver, and the Commission congratulated itself upon "finding an excellent food, a food that is practically the same as that giving nutriment to the embryo while within the egg." In the report of the Rhode Island Fish Commission for 1900, Dr. H. C. Bumpus observes that "It is a well-known fact that the food-yolk of the lobster's egg is finally stored in the liver of the growing embryo, and at the time of hatching the supply of this material is nearly exhausted. The liver of the adult lobster (the greenish-colored gland, so delicious to the taste, and often called the "fat") is made up of a number of short fibers, which may be readily cut up into morsels practically microscopic. These float about in

the water and are easily devoured by the fry, a single liver being sufficient to feed many thousands" ( p. 44).

### *b. Young Fish.*

The liver of the lobster seemed at first a fairly good food for the young lobster fry, but it has several objectionable features. Not only does the use of the liver involve the sacrifice of adult lobsters, but the uneaten liver rapidly decays and pollutes the water. Moreover, it was observed that as the lobsters become older they seem to flourish better on living food than on the prepared liver.

This suggested the use of young fish. These seemed in many respects an ideal food, for the fish fry liberated in the hatching bags could be eaten at any time by the young lobsters. Unfortunately this experiment was not a success. In searching for a fish whose young could be raised for food, the goose-fish was selected. But when the young fish were finally obtained, it was found that the lobsters would not eat them. It was believed that the lobsters were not attracted by the young goose-fish on account of its dark color.

Reference has been made to the early use of shredded codfish. Other adult fish were also used for food. It is true that the flesh of various fishes is readily eaten by the lobster, but its use is not practical on account of the oil which exudes from the fish and fills the water in the rearing bags.

### *c. Copepods and Other Surface-Swimming Organisms.*

Experiments were also made with copepods and other organisms swimming near the surface of the sea. They were readily caught in large quantities by drawing a fine-meshed net along the surface of the water. These organisms furnish a natural food. The young lobster's preference for copepods has recently been clearly shown by Dr. L. W. Williams.* In his examination of the stomach contents

* L. W. Williams, "The Stomach of the Lobster and the Food of the Larval Lobster." 37th Annual Report of the Rhode Island Commission of Inland Fisheries, 1907, p. 153–181, 10 Plates.

of 100 larval lobsters he found 37 per cent. of the lobsters with copepods and only 8 per cent. with clam; 4 per cent. with insects, 3 per cent. with parts of lobsters which they had eaten in a cannibalistic manner; the stomach contents of 11 per cent. of the lobsters contained matter classed as "unrecognizable," and the stomachs of the remaining 28 per cent. were empty (p. 177).

In spite of the fact, however, that these free-swimming organisms furnish a normal food, the practical difficulty and uncertainty of securing a constant supply has not favored utilizing this natural food on any large scale, as would be necessary in the lobster hatching. Moreover, in catching the copepods it is practically impossible to prevent taking other undesirable organisms in the net, such as diatoms and shrimp. Both of these organisms are injurious to the young lobsters, for the diatoms attach themselves to the lobsters and greatly retard their growth, and the shrimp eat them.

### *d. The Soft-Shelled Clam.*

One of the most satisfactory foods thus far tried has been the soft-shelled clam. Dr. A. D. Mead, of Brown University, in his report as director of Experiment Station of the Rhode Island Fish Commission for 1902, observes "that the fry decidedly prefer an animal to a vegetable diet, and in providing an animal food it is necessary to select a tissue which can easily be shredded or crumbled into small pieces. . . . The best food so far discovered is the soft parts of clams. The bodies of the clams are cut out and chopped into fine pieces in a chopping tray, and then thrown into the water" (p. 38*).

Since 1902 the clam has been adopted as the best food for lobster rearing purposes. Mr. E. W. Barnes, assistant superintendent of the Wickford Experiment Station, has described among the advantages of the soft-shelled clam as a food, its lightness and absence

* 32nd Annual Report of the Rhode Island Commission of Inland Fisheries, 1902.

of oil, and as compared with other foods, being less subject to ready decay, and easily kept floating in the water (p. 147*).

## II. Can the Present Feeding-Methods Be Improved?

Although the soft-shell clam has thus been found to be the most serviceable of the foods so far tried, the question still remains whether the clam is in every respect the best available food.

It is evident that the food which is to prove most satisfactory for the purposes of lobster culture as developed at the Rhode Island hatchery, must furnish:

(*a*) A maximum rapidity in growth and moulting at

(*b*) A minimum expense;

(*c*) A minimum of objectionable material such as unedible tissues which decay and pollute the water;

(*d*) Lightness, to enable the lobsters to secure the food before it sinks, and

(*e*) Certainty of a sufficient and constant supply.

With reference to these requirements, the writer was asked by Dr. A. D. Mead to further investigate the comparative value of different foods. For this purpose the following experiments were made during the summer of 1907:

## III. Experiments to Compare the Effect of Different Foods upon the Growth of Fourth-Stage Lobsters.

### *a. Methods.*

About 90 young lobsters were used in these experiments. These lobsters had all moulted to the fourth stage on June 25, 1907. By selecting a hatching bag in which the lobsters, perhaps 20,000 or more, were all known to be in a given stage, it was possible to obtain

* E. W. Barnes: Methods of Protecting and Propagating the Lobster, with a Brief Outline of its Natural History. 36th Annual Report of the Rhode Island Commission of Inland Fisheries, 1906, p. 119–152. 18 Plates.

a large number of lobsters which had moulted to the same stage on the same day. Care was also taken to select only normal individuals, for it had been previously discovered that the process of regeneration which follows the loss of limbs tends to materially retard the lobster's growth.*

These 90 fourth-stage lobsters were then separated into six groups of 15 lobsters each. Five of these groups of lobsters were fed with different kinds of food. The remaining group was kept as a control.

It was attempted to conduct the experiments under constant and, at the same time, as nearly normal conditions as possible. Each lobster was kept in a separate glass jar. These jars or bottles were placed in a wooden frame not unlike an egg-crate. This frame, with its 90 or more jars, was then submerged to a distance of about two feet below the surface of the water, in order to secure a continual change of water. This necessitated a cover of some sort over the mouths of the jars to prevent the escape of the lobsters. A good deal of difficulty was experienced in finding a satisfactory cover. At first caps of copper screen were placed over some of the jars containing lobsters, for a preliminary test. But upon examination, about twelve hours later, we were surprised and disappointed to find every lobster dead. Apparently the chemical products produced by the contact of the copper with salt water had been sufficient to poison the animals. Galvanized wire screen was next tried, but with almost equally disastrous results; for within twenty-four hours the second lot of lobsters had also died. After several experiments, a cover of loose-meshed cloth, "bobbinet," was tried. This proved successful.

The lobsters were fed once a day. Before feeding, each jar was carefully cleaned in order to remove particles of food and sediment which always collect at the bottom of the jar. The food was then

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* Emmel, V. E,. '05: The Regeneration of Lost Parts in the Lobster; 35th Annual Report of the Rhode Island Fish Commission. 1906: The Relation of Regeneration to the Molting Process in the Lobster; 36th Annual Report of the Rhode Island Commission of Inland Fisheries.

cut into small pieces about an eighth of an inch in diameter, and one of these pieces placed in each jar.

In order to determine to what extent the lobsters might have derived food from the copepods and other organisms which could get into the jars, one group of lobsters was retained as a control.

These lobsters were kept under exactly the same conditions as all the other lobsters, except that they were not fed, their only source of food being the organisms which may have gotten into the jars from the outside. That the amount of food thus derived from external sources must have been very small indeed is clearly demonstrated in the results about to be presented.

Observations were made twice a day, and a record kept for the date of moult for each individual. Occasionally a lobster was moulting at the time of observation, but usually the moult had occurred during the interval between two successive observations; in this case the date of the first observation after moulting was recorded as the date of moult.

### *b. Results.*

The results of these experiments have been tabulated in the following form. By "moulting period" is meant the number of days intervening between the third and fourth moults. Since in these experiments both the age and size of the lobsters, and the temperature of the water, were practically the same for each group of lobsters, the length of this "moulting period" may be regarded as a fairly accurate indication of the effect of the different foods upon the rate of growth.

## 1. SOFT-SHELLED CLAMS.

### Table I.

*Growth of Fourth Stage Lobsters Fed on the Muscle of the Soft-Shelled Clams.*

| Number. | Moulted to Fourth Stage. | Moulted to Fifth Stage. | Length of the Moulting Period. |
|---|---|---|---|
| 1 | June 25, 8 A. M. | July 4, 8 P. M. | 9.5 days |
| 2 | June 25, 8 A. M. | July 4, 8 P. M. | 9.5 days. |
| 3 | June 25, 8 A. M. | July 5, 8 P. M. | 10.5 days. |
| 4 | June 25, 8 A. M. | July 5, 8 P. M. | 10.5 days. |
| 5 | June 25, 8 A. M. | July 5, 8 P. M. | 10.5 days. |
| 6 | June 25, 8 A. M. | July 5, 8 P. M. | 10.5 days. |
| 7 | June 25, 8 A. M. | July 5, 8 P. M. | 10.5 days. |
| 8 | June 25, 8 A. M. | July 5, 8 P. M. | 10.5 days. |
| 9 | June 25, 8 A. M. | July 5, 8 P. M. | 10.5 days. |
| 10 | June 25, 8 A. M. | July 6, 8 P. M. | 11.5 days. |
| 11 | June 25, 8 A. M. | July 7, 8 P. M. | 12.5 days. |
| 12 | June 25, 8 A. M. | July 7, 8 P. M. | 12.5 days. |
| 13 | June 25, 8 A. M. | July 7, 8 P. M. | 12.5 days. |
| 14 | June 25, 8 A. M. | July 8, 8 P. M. | 13.2 days. |
| 15 | June 25, 8 A. M. | July 9, 8 P. M. | 14.5 days. |

Average length of moulting period, 11.3 days.

## 2. BEEF.

### Table II.

*Growth of Fourth Stage Lobsters Fed on Beef.*

| Number. | Moulted to Fourth Stage. | Moulted to Fifth Stage. | Length of the Moulting Period. |
|---|---|---|---|
| 1 | June 25, 8 A. M. | July 4, 8 P. M. | 9.5 days. |
| 2 | June 25, 8 A. M. | July 4, 8 P. M. | 9.5 days. |
| 3 | June 25, 8 A. M. | July 5, 8 P. M. | 10.5 days. |
| 4 | June 25, 8 A. M. | July 6, 8 A. M. | 11.0 days. |
| 5 | June 25, 8 A. M. | July 6, 8 A. M. | 11.0 days. |
| 6 | June 25, 8 A. M. | July 6, 8 A. M. | 11.0 days. |
| 7 | June 25, 8 A. M. | July 6, 8 A. M. | 11.0 days. |
| 8 | June 25, 8 A. M. | July 6, 8 A. M. | 11.0 days. |
| 9 | June 25, 8 A. M. | July 6, 8 A. M. | 11.0 days. |
| 10 | June 25, 8 A. M. | July 6, 10 A. M. | 11.0 days. |
| 11 | June 25, 8 A. M. | July 6, 8 P. M. | 11.5 days. |
| 12 | June 25, 8 A. M. | July 6, 8 P. M. | 11.5 days. |
| 13 | June 25, 8 A. M. | July 7, 8 P. M. | 12.5 days. |
| 14 | June 25, 8 A. M. | July 7, 8 P. M. | 12.5 days. |
| 15 | June 25, 8 A. M. | July 8, 8 P. M | 13.5 days. |

Average length of moulting period, 11.2 days.

## 3. LOBSTER'S MUSCLE.

### Table III.

*Growth of Fourth Stage Lobsters Fed on Shredded Lobster's Muscle.*

| Number. | Moulted to Fourth Stage. | Moulted to Fifth Stage. | Length of the Moulting Period. |
|---|---|---|---|
| 1 | June 25, 8 A. M. | June 27, died. | ........ |
| 2 | June 25, 8 A. M. | July 5, 8 P. M. | 10.5 days. |
| 3 | June 25, 8 A. M. | July 5, 8 P. M. | 10.5 days. |
| 4 | June 25, 8 A. M. | July 5, 8 P. M. | 10.5 days. |
| 5 | June 25, 8 A. M. | July 5, 8 P. M. | 10.5 days. |
| 6 | June 25, 8 A. M. | July 6, 8 A. M. | 11.0 days. |
| 7 | June 25, 8 A. M. | July 6, 8 P. M. | 11.5 days. |
| 8 | June 25, 8 A. M. | July 6, 8 P. M. | 11.5 days. |
| 9 | June 25, 8 A. M. | July 6, 8 P. M. | 11.5 days. |
| 10 | June 25, 8 A. M. | July 6, 8 P. M.* | 11.5 days. |
| 11 | June 25, 8 A. M. | July 6, 8 P. M. | 11.5 days. |
| 12 | June 25, 8 A. M. | July 7, 8 A. M. | 12.0 days. |
| 13 | June 25, 8 A. M. | July 7, 8 P. M. | 12.5 days. |
| 14 | June 25, 8 A. M. | July 7, 8 P. M. | 12.5 days. |
| 15 | June 25, 8 A. M. | July 8, 8 P. M. | 13.5 days. |

Average length of moulting period, 11.5 days.
* Died while moulting.

## 4. SHREDDED FISH.

### Table IV.

*Grouth of Fourth Stage Lobsters Fed on Shredded Fish.**

| Number. | Moulted to Fourth Stage. | Moulted to Fifth Stage. | Length of the Moulting Period. |
|---|---|---|---|
| 1 | June 25, 8 A. M. | July 4, 8 P. M. | 9.5 days. |
| 2 | June 25, 8 A. M. | July 5, 8 P. M. | 10.5 days. |
| 3 | June 25, 8 A. M. | July 5, 8 P. M. | 10.5 days. |
| 4 | June 25, 8 A. M. | July 6, 8 A. M. | 11.0 days. |
| 5 | June 25, 8 A. M. | July 6, 8 A. M. | 11.0 days. |
| 6 | June 25, 8 A. M. | July 6, 8 P. M. | 11.5 days. |
| 7 | June 25, 8 A. M. | July 6, 8 P. M. | 11.5 days. |
| 8 | June 25, 8 A. M. | July 6, 8 P. M. | 11.5 days. |
| 9 | June 25, 8 A. M. | July 6, 8 P. M. | 11.5 days. |
| 10 | June 25, 8 A. M. | July 7, 6 A. M. | 11.9 days. |
| 11 | June 25, 8 A. M. | July 7, 8 P. M. | 12.5 days. |
| 12 | June 25, 8 A. M. | July 7, 8 P. M. | 12.5 days. |
| 13 | June 25, 8 A. M. | July 8, 1 A. M. | 12.7 days. |
| 14 | June 25, 8 A. M. | July 8, 8 P. M. | 13.5 days. |
| 15 | June 25, 8 A. M. | July 8, 8 P. M. | 13.5 days. |

Average length of moulting period, 11.7 days.
* The fish used was the common mummichog, *Fundulus heteroclitus*

## 5. BEEF LIVER.

### Table V.

*Growth of Fourth Stage Lobsters Fed on Beef Liver*

| Number. | Moulted to Fourth Stage. | Moulted to Fifth Stage. | Length of the Moulting Period. |
|---|---|---|---|
| 1 | June 25, 8 A. M. | July 5, 8 P. M. | 10.5 days. |
| 2 | June 25, 8 A. M. | July 6, 8 A. M. | 11.0 days. |
| 3 | June 25, 8 A. M. | July 6, 8 A. M | 11.0 days. |
| 4 | June 25, 8 A. M. | July 6, 8 A. M. | 11.0 days. |
| 5 | June 25, 8 A M. | July 6, 8 P. M. | 11.5 days. |
| 6 | June 25, 8 A. M. | July 6, 8 P. M. | 11.5 days |
| 7 | June 25, 8 A. M. | July 6, 8 P. M. | 11.5 days. |
| 8 | June 25, 8 A. M. | July 7, 8 P. M. | 12.5 days. |
| 9 | June 25, 8 A. M. | July 7, 8 P. M. | 12.5 days. |
| 10 | June 25, 8 A. M. | July 7, 8 P. M. | 12.5 days. |
| 11 | June 25, 8 A. M. | July 7, 8 P. M. | 12.5 days. |
| 12 | June 25, 8 A. M. | July 7, 8 P. M. | 12.5 days. |
| 13 | June 25, 8 A. M. | July 8, 8 P. M. | 13.5 days. |
| 14 | June 25, 8 A. M. | July 8, 8 P. M | 13.5 days. |
| 15 | June 25, 8 A. M. | July 9, 8 P. M. | 14.5 days. |
| 16 | June 25, 8 A.M. | July 10 6 P. M. | 15.2 days. |

Average length of moulting period, 12.3 days.

### Table VI.

*Growth of Fourth Stage Lobsters Which were Kept Without Any Food except what may have been Derived from the Organisms Floating in the Water.*

| Number. | Moulted to Fourth Stage. | Moulted to Fifth Stage. | Length of the Moulting Period. |
|---|---|---|---|
| 1 | June 25, 8 A. M. | July 9, 8 A. M. | 14.0 days. |
| 2 | June 25, 8 A. M. | July 9, 8 A. M. | 14.0 days. |
| 3 | June 25, 8 A. M. | July 12, 8 P. M. | 17.0 days. |
| 4 | June 25, 8 A M. | July 14, 8 P. M. | 19.0 days. |
| 5 | June 25, 8 A. M. | July 15, 6 A. M. | 19.9 days. |
| 6 | June 25, 8 A. M. | July 15, 11 P. M. | 20.6 days. |
| 7 | June 25, 8 A M. | July 17, 8 P. M. | 22.5 days. |
| 8 | June 25, 8 A. M. | July 17, 9 P. M. | 22.5 days. |
| 9 | June 25, 8 A. M. | July 18, 7 A. M. | 23.0 days. |
| 10 | June 25, 8 A. M | July 19, 9 P. M. | 24.5 days.* |
| 11 | June 25, 8 A. M. | July 23, 8 P. M. | 28.5 days * |
| 12 | June 25, 8 A. M. | July 25, died | 29.0 days.* |
| 13 | June 25, 8 A. M. | July 28, died | 33.0 days.* |
| 14 | June 25, 8 A. M. | July 28, died | 33.0 days.* |
| 15 | June 25, 8 A. M. | August 1, died | 36.0 days.* |

Average length of moulting period, 24.6 days.*

* Nos. 12–15 have been included in this data because the long delay in the moulting of these four lobsters was also undoubtedly due to the lack of sufficient food.

### *c. Discussion of Results.*

The results of these experiments show that the average length of the moulting period of these fourth-stage-lobsters when fed on different food, was as follows:

| | |
|---|---|
| Beef | 11.2 days. |
| Soft-shelled clam | 11.3 days. |
| Lobster's muscle | 11.5 days. |
| Shredded fish | 11.7 days. |
| Beef liver | 12.3 days. |

That all other food factors, except the particular food used in each case, were practically eliminated in these results is demonstrated by the fact that the average length of the moulting period for the lobsters which were not fed was over *twice as long*, or 24.6 days.

It is evident, therefore, that in these experiments the clam, beef, lobster muscle, and fish were practically equal in food value, with perhaps a slight advantage in favor of beef. The beef liver was the least satisfactory—a rather unexpected result, for beef liver is successfully used in trout hatcheries, and it was hoped it might prove equally satisfactory for the lobster.

Reviewing these results with reference to the choice of a food for the lobsters, it is evident that lobster muscle and fish may be withdrawn from further consideration. For these foods do not appear to be any more nutritive than clam or beef, and the necessary sacrifice of adult lobsters in the use of the former and the oily character of the fish discredit their use for practical purposes. Liver certainly is the cheapest food, but it seems to be the least nutritive, and, moreover, it was observed to decay more quickly than other foods. It appears, therefore, that the only remaining food tried which might prove an improvement over the present use of the soft-shelled clam is beef.

In view of these results it was thought desirable to further test the comparative value of beef and clam for the practical work of

lobster rearing. This has been done in the following experiments.

I desire here to express my indebtedness to Mr. L. N. Wight, through whose assistance these experiments were brought to a successful conclusion.

## IV. Experiments to Determine the Comparative Value of Beef and Clam for Rearing Newly Hatched Lobsters.

### a. *Experiments and Results.*

In order to test the comparative food value and actual cost of beef and clam, the following experiments were made in two of the regular rearing bags of the lobster hatchery.

These rearing bags are made of canvas. Each bag is about eleven feet square and four feet in depth, with three windows of fine-mesh copper wire netting, one window being on the bottom and one on each of two opposite sides of the bags. A two-bladed paddle, not unlike a restaurant fan, is kept revolving slowly in each bag. The current of water thus created by the paddle serves not only to change the water in each bag, but also tends both to keep the food in circulation and at the same time to prevent the lobster fry from settling to the bottom.

Two of the rearing bags were selected for the present experiments. On July 11th, 40,000 lobsters which had just hatched were carefully counted from the hatching bags; 20,000 of these first stage lobsters were placed in each of the two rearing bags.

All of the conditions in these two rearing bags were kept as nearly alike as possible. The lobsters in one bag were fed with the soft parts of the clam, which had been cut out from the shell and finely ground in a meat grinder. The lobsters in the second bag were fed finely ground beef. Food was given three or four times in every twenty-four hours. In order to obtain an accurate estimate of the cost, the food was carefully weighed.

The lobsters were kept in the rearing bags until they had all moulted to the fourth stage, June 24. These lobsters were then

counted, and it was found that out of the 20,000 clam-fed lobsters 7,818 had lived to the fourth stage, while out of the 20,000 beef-fed lobsters 8,125 had lived to the fourth stage. In other words, 4 per cent. more fourth-stage lobsters were obtained from the fry fed on beef than from the fry fed on clam.

### *b. Comparative Cost.*

The actual amount and cost of the beef and clam used in each experiment is shown in the following records:

TABLE VII.

*Showing Amount of Beef and Clam used in Rearing 40,000 Lobsters.*

| | | Rearing Bag No. 1. Amount of clams fed. | Rearing Bag No. 2. Amount of beef fed. |
|---|---|---|---|
| July 12, | 1 A. M | 110 grams. | 110 grams. |
| | 6 A. M | 220 grams. | 220 grams. |
| | 1 P. M. | 110 grams. | 110 grams. |
| | 10 P. M. | 110 grams | 110 grams. |
| 13, | 4 A. M | 110 grams. | 110 grams. |
| 13, | 9 A. M | 110 grams. | 110 grams. |
| | 8 P. M. | 110 grams. | 110 grams. |
| 14, | 1 A. M | 110 grams. | 110 grams. |
| | 4 A M | 110 grams | 101 grams. |
| | 10 A. M | 110 grams. | 110 grams. |
| | 8 P. M. | 110 grams. | 110 grams. |
| 15, | 1 A. M | 110 grams | 110 grams. |
| | 4 A. M | 110 grams. | 110 grams. |
| | 9 P. M. | 110 grams | 110 grams. |
| | 12 P. M. | 110 grams. | 110 grams. |
| 16, | 4 A. M | 110 grams. | 110 grams. |
| | 8 P. M. | 110 grams. | 110 grams. |
| 17, | 1 A. M | 110 grams. | 110 grams. |
| | 4 A. M | 110 grams. | 110 grams. |
| | 7 A. M | 110 grams. | 110 grams. |
| | 9 P. M. | 110 grams. | 110 grams. |
| 18, | 1 A. M | 110 grams. | 110 grams. |

| | | Rearing Bag No. 1. Amount of clams fed. | Rearing Bag No. 2. Amount of beef fed. |
|---|---|---|---|
| | 5 A. M | 110 grams. | 110 grams. |
| | 8 P. M. | 110 grams. | 110 grams. |
| 19, | 1 A. M | 110 grams. | 110 grams. |
| | 5 A. M | 110 grams. | 110 grams. |
| | 8 P. M | 110 grams. | 110 grams. |
| 20, | 5 A. M | 110 grams* | 110 grams. |
| | 9 P. M. | 110 grams. | 110 grams. |
| 21, | 1 A M | 110 grams | 110 grams. |
| | 5 A. M | 110 grams. | 110 grams. |
| | 8 P. M. | 110 grams* | 110 grams. |
| 22, | 4 A. M | 110 grams* | 110 grams. |
| | 8 P. M | 50 grams* | † 50 grams. |
| 23, | 4 A. M | 50 grams* | † 50 grams. |
| | 8 P. M. | 50 grams* | † 50 grams. |
| 24, | 4 A. M | 50 grams* | † 50 grams. |
| Total | | 3,980 grams | 3,980 grams. |

The beef cost 12 cents a pound. Consequently the total cost of the beef used in these experiments, 3,980 grams, was $1.05.

The cost of the clams varied from $1.25 to $1.50 a bushel. The average price may therefore be taken as about $1.35 per bushel. The soft parts of a bushel of clams when cut out of the shell were found to weigh about 4,830 grams. The 3,980 grams of ground clam fed in the experiments, therefore, equals .824 bushel of clams in the shell, and, at $1.35 a bushel, cost $1.11. To this must be added the labor of cutting out the clams from the shell, an item of expense which is not involved in using beef. Cutting out a bushel of average size clams requires about two hours labor, which, even at 15 cents an hour, gives an additional expense of about 25 cents. So that the total cost of the clam used in the experiment amounts to $1.35.

In these experiments, therefore, the clams cost 28 per cent. more than the beef. At the same time 4 per cent. more lobsters were

* In these cases beef was used because fresh clams were not available at the time.

† On July 22 a large number of fourth stage lobster were removed from the bags and the amount of food was accordingly reduced.

reared to the fourth stage from the beef-fed lobsters than from the lobsters fed with clams.

Another item which must not be overlooked in comparing these results is that of waste. In the clam, the siphon, or "snout," and other cuticular tissues form a considerable part of its flesh. These cuticular structures, as Dr. L. W. Williams has observed, are "regularly rejected by the lobster," and only eaten in the absence of other food.* In beef there is a much smaller amount of such inedible material, consequently there is much less waste involved in feeding beef than clam.

The subject of supply is also a matter of considerable practical importance. The supply of clam is more irregular and uncertain than beef. For in securing fresh clams dependence is placed on the local clamdigger, but on account of tide and weather and other exigencies, the hatchery is frequently short in the supply of fresh clams. On the other hand, fresh beef is always available in the markets.

## V. Summary and Conclusions.

A series of experiments was made to test the value of different foods for rearing young lobsters. The following results were obtained:

1. It was found that fourth-stage lobsters grew as well when fed on beef, if not better, than when fed on clam, fish, lobster muscle, or beef liver.

2. In an experiment with 40,000 lobsters just hatched, 4 per cent. more lobsters were reared to the fourth stage from the beef-fed, than from the clam-fed lobsters.

3. The beef cost 28 per cent. less than the clam.

4. These results suggest the adoption of beef instead of clam as a food for rearing young lobsters, for the following reasons:

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* L. W. Williams: "The Stomach of the Lobster and the Food of Larval Lobsters." 37th Annual Report of the Rhode Island Commission of Inland Fisheries, 1907, p. 153–180.

*a.* Lobsters can be as successfully reared on beef as on clam.

*b.* Beef is much cheaper.

*c.* There is more inedible waste material in clam than in an equal weight of beef.

*d.* This waste material is especially undesirable because it favors the growth of algæ and sessile diatoms, injurious to the lobster fry.

*e.* In practical work there is greater regularity and certainty in securing a constant supply of beef than there is in the case of clam.

5. It may be added that, as the result of these experiments, it has been decided, in next season's work at the lobster hatchery, to give beef a thorough trial as a food for rearing lobster fry.

## The Salt-Water Aquarium and Sea-Farming Exhibit at the Washington County Fair.

For the fourth year the Commission has made an exhibit at the annual fair of the Washington County Agricultural Association, under the suggestive title of "sea farming."

The main feature of the exhibit for the year 1907 was the salt-water aquarium. After a large amount of experimenting a scheme was put into operation which provided a constant current of clear salt water in the aquarium, in which fishes and invertebrates of various kinds lived for four or five days without the usual signs of sluggishness and sickness.

The several miles distance from the sea and fact that the aquarium is necessarily of temporary and inexpensive installation created a new problem in aquarium management, but the combined efforts of the president of the agricultural association, one of the members of this Commission, superintendent of the Wickford station, and the very willing and ingenious corps of assistants have brought success out of the many difficulties.

The exhibit we feel is worth the trouble, for it affords a means of instruction and stimulation of interest to many thousands of the citizens of the State.

# APPENDIX A.

## UNITED STATES BUREAU OF FISHERIES,

WASHINGTON, D. C.

*Commissioner.*

GEORGE M. BOWERS.

*Deputy Commissioner.*

HUGH M. SMITH.

*Chief Clerk.*

I. H. DUNLAP.

*Assistant in Charge of Division of Inquiry Respecting Food Fishes.*

B. W. EVERMANN.

*Assistant in Charge of Division of Fish Culture.*

JOHN W. TITCOMB.

*Assistant in Charge of Division of Statistics and Methods of the Fisheries.*

A. B. ALEXANDER.

*Architect and Engineer.*

HECTOR VON BAYER.

# STATE FISHERIES AUTHORITIES.

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**(List based upon most recent information at hand, date of which is given for each state.)**

---

## ALABAMA.

*State Game and Fish Commissioner* (1907).

John H. Wallace, Jr. . . . . . . . . . Montgomery.

## ARIZONA.

*Fish and Game Commission* (1905).

T. S. Bunch . . . . . . . . . . Safford.
Eugene Allison . . . . . . . . . . Jerome.
L. W. Penny, Secretary . . . . . . . . . . Phœnix.

## CALIFORNIA.

*California Fish Commission* (*December*, 1906).

W. W. Van Arsdale, President . . . . . . . . . . San Francisco.
W. E. Gerber . . . . . . . . . . Sacramento.
John Bermingham . . . . . . . . . . Pinole.
Charles A. Vogelslang, Chief Deputy . . . . . . . . . . San Francisco.

## COLORADO.

*Department of Game and Fisheries* (*May*, 1907).

David E. Farr, Commissioner . . . . . . . . . . Denver.
C. W. Lake, Deputy Commissioner . . . . . . . . . . Denver.
R. L. Spargier, Chief Clerk . . . . . . . . . . Denver.
W. S. Kincaid, General Superintendent, State Hatcheries. Denver.

## CONNECTICUT.

*Department of Fish and Game (December,* 1906).

George T. Mathewson, President........................Thompsonville.
Robert G. Pike........................................Middletown.
E. Hart Geer, Secretary...............................Hadlyme.

*Connecticut Shellfish Commission* (1906).

George C. Waldo.......................................Bridgeport.
Christian Schwartz....................................South Norwalk.
William J. Atwater....................................New Haven.

## FLORIDA.

*Florida Fish Commission* (1907).

John Y. Detwiler, Honorary Commissioner..............New Smyrna.

## GEORGIA.

*Superintendent of Fisheries (December,* 1906).

A. T. Dallis..........................................La Grange.

## IDAHO.

*State Fish and Game Warden* (1906).

W. N. Stephens........................................Rexburg.

## ILLINOIS.

*Board of State Fish Commissioners* (1907).

Nat H. Cohen, President...............................Urbana.
Henry Kleine..........................................Chicago.
S. P. Bartlett, Secretary and Superintendent..........Quincy.

## INDIANA.

*Commissioner of Fisheries and Game (December,* 1906).

Z. T. Sweeney.........................................Columbus.

## Iowa.

*State Fish and Game Warden* (*December*, 1906).

George A. Lincoln.................................Cedar Rapids.

## Kansas.

*State Fish Warden* (*December*, 1906).

D. W. Travis.......................................Pratt.

## Louisiana.

*Oyster Commission of Louisiana* (1907).

J. M. Breaux, President.............................Houma.
Clement Story.......................................Melonie.
Horace H. Harvey....................................Harvey.
Ben Michel..........................................Pilottown.
A. E. Hoffman.......................................Thibodaux.

## Maine.

*Commissioners of Inland Fisheries* (*December*, 1906).

Leroy T. Carleton, Chairman.........................Augusta.
J. W. Brackett......................................Phillips.
Edgar E. Ring, Secretary............................Orono.

*Commissioner of Sea and Shore Fisheries* (*December*, 1906).

James Donohue.......................................Rockland.

## Maryland.

*State Fish Commission* (1907).

J. H. Wade, Commissioner for Western Shore ............................
Samuel Twilley, Commissioner for Eastern Shore.........................

*Shellfish Commission* (1907).

Walter J. Mitchell, Chairman........................La Plata.
Benj. K. Green, Treasurer...........................Westover.
Dr. Caswell Grave, Secretary........................Baltimore.

MASSACHUSETTS.

*Commission of Fisheries and Game* (1907).

Dr. G. W Field, Chairman.............................Boston.
J. W. Delano, Superintendent of Hatcheries.............Boston.
E. A. Brackett.........................................Winchester.

MICHIGAN.

*State Board of Fish Commissioners* (*December*, 1906).

C. D. Joslin, President................................Detroit.
F. B. Dickerson, Vice-President........................Detroit.
George M. Brown........................................Saginaw.
Seymour Bower, Superintendent of Hatcheries............Detroit.

MINNESOTA.

*Board of Fish and Game Commissioners* (1907).

O. J. Johnson, President...............................St. Paul.
Carlos Avery, First Vice-President.....................St. Paul.
John H. Grill, Second Vice-President...................St. Paul.
H. G. Smith, Secretary.................................St. Paul.
S. F. Fullerton, Executive Agent.......................Duluth.

MISSOURI.

*Missouri State Fish Commission* (*March*, 1907).

Richard Porter, President..............................Paris.
W. H. Hughes, Vice-president...........................St. Louis.
J. M. Shortal, Secretary...............................St. Louis.
John Gable.............................................Browning.
William Bub............................................St. Joseph.

MONTANA.

*State Game and Fish Warden* (*December*, 1906).

W. F. Scott............................................Helena.

NEBRASKA (*December*, 1906).

Governor, Commissioner *ex-officio*......................Lincoln.
George L. Carter, Chief Warden.........................Lincoln.
W. J. O'Brien, Superintendent of Hatcheries............Gretna.

## New Hampshire.

*Fish and Game Commission* (1906).

Nathaniel Wentworth, Chairman........................Hudson Center.
Charles B. Clark, Financial Agent........................Concord.
Merrill Shurtleff, Secretary........................Lancaster.

## New Jersey.

*Fish and Game Commission* (1907).

B. P. Morris........................Long Branch.
R. T. Miller........................Camden.
D. P. McClellan........................Morristown.
P. H. Johnson........................Bloomfield.
J. M. Stratton, Fish and Game Protector........................Long Branch.

*State Bureau of Shell Fisheries.*

Charles R. Bacon, Chief........................Camden.
E. T. Riley........................Newport.
E. L. Stites, Jr........................Fort Norris.
Jeremiah N. Ogden........................Bridgeport.
Wm. De Groff........................Keyport.
A. T. Bacon, Superintendent of Hatcheries........................Mauricetown.

## New York.

*Forest, Fish and Game Commission* (1907).

Jas. S. Whipple, Commissioner........................Albany.
J. Duncan Lawrence, Deputy Commissioner........................Albany.
John D. Whish, Secretary........................Albany.
Dr. T. H. Bean, State Fish Culturist...1 Madison Avenue, New York.
B. Frank Wood, Superintendent of Shell Fisheries........................Jamaica.
Wm. F. Fox, Superintendent of Forests........................Albany.

## Nevada.

*State Fish Commissioners* (1907).

George T. Mills........................Carson.
E. B. Yerington........................Carson.
H. H. Coryell........................Wells.

## North Carolina.

*State Fish Commissioner* (1907).

Theodore S. Meekins.................................Manteo.

*Shellfish Commissioner* (1907).

W. M. Webb.....................................Morehead City.

## North Dakota.

*Game Wardens* (1905).

F. W. Schlechter..................................Fessenden.
Wm. McKean......................................Sanborn.

## Ohio.

*Fish and Game Commission* (1906).

Paul North, President.............................Cleveland.
T. B. Paxton......................................Cincinnati.
D. W. Green.......................................Dayton.
George McCook....................................Steubenville.
J. F. Rankin.......................................South Charleston.

## Oklahoma.

*Territorial Game and Fish Warden* (1907).

Eugene Watrous....................................Enid.

## Oregon.

*Board of Fish Commissioners.*

Governor..........................................Salem.
Secretary of State.................................Salem.
State Treasurer....................................Salem.

*Master Fish Warden* (1907).

H. G. Van Dusen..................................Astoria.

## Pennsylvania.

*Department of Fisheries* (1907).

W. E. Meehan, Commissioner........................Harrisburg.
John Hamberger...................................Erie.

Henry C. Cox.......................................Wellsboro.
Andrew R. Whitaker.................................Phoenixville.
W. A. Leisenring...................................Mauch Chunk.

## Rhode Island.

*Commissioners of Inland Fisheries* (1907).

Henry T. Root, President, Treasurer and Auditor........Providence.
J. M. K. Southwick, Vice-president.....................Newport.
Charles W. Willard.....................................Westerly.
A. D. Mead...........................Brown University, Providence.
W. P. Morton, Secretary................P. O. Box 966, Providence.
Adelbert D. Roberts....................P. O. Box 264, Woonsocket.
William H. Boardman....................................Central Falls.

*Commissioners of Shell Fisheries* (1907).

Philip H. Wilbour......................................Little Compton.
James M. Wright........................................Clayville.
John H. Northup........................................Apponaug.
George W. Hoxie........................................Shannock.
Herbert M. Gardiner....................................Barrington.

## South Carolina.

*State Board of Fisheries* (1907).

James M. Rhett, Chairman...............................Beaufort.
L. M. Gasque...........................................Marion.
George S. Mower........................................Newberry.

## Tennessee.

*State Game and Fish Warden* (1906).

Joseph H. Acklen.......................................Nashville.

## Texas.

*State Fish and Oyster Commissioner* (1907).

I. P. Kibbe............................................Port Lavaca.

## Utah.

*State Fish and Game Commissioner* (1905).

John Sharp.............................................Salt Lake City.

### Vermont.

*Commissioner of Fisheries and Game* (1907).

Henry G. Thomas.................................Stowe.

### Virginia.

*State Board of Fisheries* (1905).

W. McDonald Lee.................................Irvington.
S. Wilkins Matthews (care of Mr. Lee)................Irvington.
George B. Keezell.................................Keezletown.
Rorer A. James (care of Mr. Lee)......................Irvington.
Bland Massie (care of Mr. Lee).........................Irvington.

### Washington.

*Department of Fisheries and Game.*

*Report of Fish Commissioners.*

Governor.........................................Olympia.
State Treasurer...................................Olympia.

*State Fish Commissioner and Game Warden.*

John L. Risland...................................Bellingham.

### West Virginia.

*State Game and Fish Warden* (1905).

J. H. Marcum......................................Huntington.

### Wisconsin.

*Commissioner of Fisheries* (1907).

The Governor......................................Madison.
Calvert Spensley, President.............................Mineral Point.
James J. Hogan, Vice-president........................La Crosse.
E. A. Birge, Secretary.................................Madison.
William J. Starr...................................Eau Claire.
Henry D. Smith....................................Appleton.
Jabe Alford.......................................Madison.
A. A. Dye..........................................Madison.

# FISHERIES LAW OF RHODE ISLAND, 1905.

[Compiled by the Commissioner of Inland Fisheries.]

## GENERAL LAWS.

### CHAPTER 1.

The jurisdiction of the Commissioners of Inland Fisheries covers the territorial limits of the State as given in the following two sections of chapter one, and covers all the fisheries of the State except the oyster and scallop fisheries, which are under the jurisdiction of the shell fish commissioners.

SECTION 1. The territorial limits of this state extend one marine league from its seashore at high water mark. When an inlet or arm of the sea does not exceed two marine leagues in width between its headlands, a straight line from one headland to the other is equivalent to the shore-line. The boundaries of counties bordering on the sea extend to the line of the state as above defined.

SEC. 2. The jurisdiction of the state shall extend to, and embrace, all places within the boundaries thereof, except as to those places that have been ceded to the United States, or have been purchased by the United States with the consent of the state.

### CHAPTER 171.

*Of Certain Fisheries.*

SECTION 1. Every person who shall set or draw any seine in any part of the river running from Warren river through the town of Barrington, except that part lying north of the Congregational church building in the said town of Barrington, shall forfeit twenty dollars.

SEC. 2. Every person who shall set or draw any seine or net in Easton's pond in Newport and Middletown for the purpose of catching fish, or shall set

any such net or seine in the creeks or inlets of said pond above the bridge at Easton's beach, shall be fined twenty dollars or be imprisoned ten days.

Sec. 3. Every person who shall set or draw any seine or net in Kickamuit river within half a mile from the place called the narrows shall forfeit fifteen dollars.

Sec. 4. Every person who shall erect or make any weir, pot, or other contrivance to obstruct the course of fish across Puncatest, alias Nomquit, pond, or any part thereof, or in any river or stream leading into or out of said pond at any time, shall forfeit ten dollars.

Sec. 5. Every person who shall set any hanging or mesh net in Puncatest alias Nomquit, pond, or in any river leading into or out of said pond, between the first day of January and the first day of August, shall forfeit ten dollars.

Sec. 6. Every person who shall erect or continue in Palmer's river, above Kelly's bridge, any weir, dam, or other obstruction to prevent the free passage of fish up said river, shall forfeit fifteen dollars for the first offence and ten dollars for every twenty-four hours any such weir or dam or other obstruction shall be continued after the first twenty-four hours.

Sec. 7. Every person not at the time an inhabitant of this state who shall ret or draw any seine or net in Palmer's river, above Kelly's bridge, on Thursday, Friday, or Saturday, and every person who shall set or draw any seine or net in said river above said bridge on Sunday, or between the setting and rising of the sun, shall forfeit for each offence fifteen dollars.

Sec. 8. Repealed.

Sec. 9. Repealed.

Sec. 10. Repealed.

Sec. 11. No person shall take any fish with any kind of gill or mesh net, or set any gill or mesh net for the purpose of taking any fish therewith, within one mile from the shore of Block Island, between the first day of June and the first day of November in each year, without first obtaining permission of the town council of New Shoreham; and every person violating any provision of this section shall be fined twenty dollars for each offence; one-half to the use of the complainant and the other half to the use of the town of New Shoreham.

Sec. 12. Any person who shall take any fish with any kind of seine, net, or trap, or set or draw any seine, net, or trap, for the purpose of taking any fish therewith, in any of the fresh water ponds in the town of New Shoreham, except in private ponds owned by one person, shall be fined not exceeding twenty dollars or be imprisoned not exceeding ten days, or be both fined and imprisoned in the discretion of the court.

Sec. 13. The electors of the town of New Shoreham may, in town meeting called for that purpose, enact such ordinances as they may think proper to pro-

tect and to regulate the taking of shell-fish and other fish in Great Salt pond, and may impose penalties therefor not exceeding twenty dollars fine and three months' imprisonment for any one offence.

SEC. 14. The electors of the town of Tiverton may, in town meeting called for that purpose, make such regulations for the preservation of the fish, and may exercise such control over the fisheries of Nomquit pond, within the limits of said town, as they may think proper.

SEC. 15. No person shall, between the first Monday in October and the first Monday in January, erect any weir or draw any seine or net for the purpose of catching or obstructing the passage of fish at or within one hundred and sixty rods of the mouth of Pataquamscut river in South Kingstown, nor shall any person erect or put down any weir, standing seine, or trap-seine, or hoop-net of any kind, either within or across said river at any other season of the year.

SEC. 16. Nothing in the preceding section shall be so construed as to prohibit any person from using nets or fishing crafts for the catching of smelts, such as are commonly used in the smelt fishery, between the first day of February and the first day of April, or to prohibit the setting of gill nets for bass in said river or pond: *Provided*, that such nets shall not exceed twenty fathoms in length, nor be set within twenty fathoms of each other, nor south of the dividing line between lands now or formerly of William G. Watson and George W. Crandall, nor within twenty rods of the narrows that connect the upper and lower ponds; nor shall any person maintain any such standing seine or net in the same place for more than twenty-four hours if any other person demands the same place for the purpose of setting a like net or drawing a seine therein.

SEC. 17. Every person who shall violate any of the provisions of the preceding two sections shall be fined not less than twenty dollars nor more than fifty dollars for each offence, and shall forfeit the seine, net, boat, and other apparatus by him used in such violation.

SEC. 18. Every person who shall set any trap or net or draw any seine at any time west of a line drawn from Calf-pasture Point on the north side of Allen's harbor to Rocky Point on the south side thereof, or west of a line drawn from Pojack Point on the south side of Potowomut river to Marsh Point on the north side thereof, shall be fined not less than five dollars nor more than twenty dollars; one-half thereof to the use of the complainant and one-half thereof to the use of the state.

SEC. 19. No person shall between the fifteenth day of April and the fifteenth day of June, inclusive of both days, or between the fifteenth day of August and the fifteenth day of December, inclusive of both days, commencing at the rising of the sun on both days, erect any weir or set or draw any seine or net for obstructing, catching, or hauling of fish within half a mile east from Point Judith ponds

breach, meaning the breach for the time being into the sea, or within a point on the west side of said breach four rods distant from Joseph Champlin's fish-house, so called, or within said breach, or within any channel leading to said ponds, or any branch thereof from the sea, or within a quarter of a mile of the entrance of such channel into said ponds or branches of said ponds; and whenever the fifteenth day of December happens on Sunday this prohibition shall continue to the rising of the sun on the next succeeding day.

SEC. 20. No weir shall be erected, nor any standing seine or net set, in any part of Charlestown pond, Quonochontaug pond, or Babcock's pond, otherwise know as Brightman's pond, nor across the channel, or in Point Judith's ponds within a quarter of a mile from the following places, namely: Alder Point near where Saukatucket river flows into said ponds; Princes narrows, which connects the upper with the lower ponds; Strawberry hill on Great Island; High Point, so-called, on lands of the heirs of Joseph Sherman, and Gooseberry Hole.

SEC. 21. No person shall, between sunset on the first Monday in April and sunrise on the second Monday in June, erect any weir or net or draw any seine or net for the purpose of catching or obstructing the passage of fish in any part of Point Judith pond south of a line drawn from the most northerly point of Strawberry hill on Great Island to the most northerly point of High Point in said pond.

SEC. 22. No person shall erect any weir or set or draw any seine or net for the obstructing, catching, or hauling of fish within any part of said ponds or any branch thereof, at any time between sunset on the fifteenth day of August and sunrise on the fifteenth day of December.

SEC. 23. No seine or net of any sort shall be used at any time within said ponds or any branch thereof, of over one hundred fathoms in length, nor any standing seine or net of over twenty-five fathoms in length.

SEC. 24. No person shall set any standing seine or net, at any time, within forty rods of any place within said ponds or any branch thereof where another person may have already set his standing seine or net, nor shall any person maintain any such standing seine or net in the same place for more than forty-eight hours if any other person desires to occupy the place.

SEC. 25. Every person violating any provision of the preceding six sections shall be fined not less than twenty dollars nor more than fifty dollars, and shall also forfeit the boat, seine, net, and other apparatus by him used in such violation, one-half of said fine and forfeiture to the use of the person complaining and one-half thereof to the use of the state.

SEC. 26. Every person living without the state who shall take any lobsters, tautog, bass, or other fish within the harbors, rivers, or waters of this state, for

the purpose of carrying them thence in vessels or smacks, shall be fined ten dollars for every offence, and shall forfeit all the fish or lobsters so taken.

SEC. 27. Every person who shall take any fish in any stream or fresh pond, except upon his own land, otherwise than by a single hook and line, or who shall take or carry away any fish from any private pond, brook, stream, preserve, or any other place made, constructed, or used for the purpose of breeding or growing fish therein, without the consent of the proprietor or lessee of such pond, brook, stream, or preserve, shall be fined not exceeding twenty dollars or be imprisoned not exceeding thirty days, or be both fined and imprisoned; but nothing herein contained shall be so construed as to authorize the taking of any fish from any pond or stream stocked with fish at the expense of the state.

SEC. 28. Every person who shall take any trout between the fifteenth day of July and the first day of April shall be fined twenty dollars for each offence, and every person who shall take or have in his or her possession any trout less than six inches in length at any time of the year shall be fined twenty dollars for each trout found in his or her possession, but nothing herein contained shall be so construed as to prohibit the taking and sale of trout artificially cultivated in private ponds at any season of the year: *Provided*, that all persons raising brook-trout artificially in private ponds shall use the initials of their names as a brand, which brand shall be put on every box of trout shipped or put on the market by them between the fifteenth of July and the first day of April in each year. All persons raising and disposing of trout as aforesaid shall cause their brand required herein to be registered by the secretary of state.

SEC. 29. All actions for violations of the provisions of the preceding two sections shall be commenced within thirty days after the commission of the offence.

SEC. 30. Every person who shall, by any seine or stop-net, or otherwise, obstruct the channel leading from the sea into Ward's pond, and up through said pond on each side of Watermelon, Gooseberry, or Larkin's islands, shall be fined not less than five dollars nor more than twenty dollars.

SEC. 31. Every person who shall erect any dam, weir, or other obstruction across Mill cove in Warwick, or from the mouth of said cove to the pond of fresh water that runs into said cove, or such streams as run into said pond, or who shall keep up any dam, or weir, or other obstruction therein made, and every owner or occupant of lands adjoining said Mill cove or the stream leading from said pond into said cove who shall permit any such obstruction to be erected on continued in or upon said cove or stream adjacent to his land, at any time between the first day of March and the first day of November, shall forfeit one hundred dollars for each offence.

SEC. 32. Every person who on Saturday or Sunday shall fish in said cove

except with a hook and line, or who shall catch or hinder any alewives coming down said Mill cove or said stream, or shall therein at any time set any weir or device to prevent the passage of the fish, shall forfeit ten dollars for each offence: *Provided*, that nothing herein contained shall be so construed as to authorize fishing on Sunday.

SEC. 33. Every person who shall set or draw any seine or net in said Mill cove, or off from the mouth thereof to Long Meadow rocks, or from the mouth thereof to the pond of fresh water which empties into said cove, between the first day of March and the fifteenth day of June, or who shall take any alewives from said pond, or streams flowing into said pond, between the first day of March and the first day of November in any year, shall for each offence forfeit one hundred dollars and the boats, seines, and other apparatus used in the commission thereof: *Provided, however*, that nothing in this chapter shall be so construed as to prohibit any person from fishing for alewives in said cove, or stream running from said pond into said cove, with a bowed net not larger than twelve feet around the mouth of said net, on days other than those excepted in section thirty-two of this chapter.

SEC. 34. There shall be, between the first day of May and the first day of August, a weekly close-time extending from Saturday morning at sunrise to Monday morning at sunrise, during which time no fish of any description shall be taken by weirs, traps, or similar contrivances, from any of the waters of the coast-line of the state and Narragansett bay. If there be any weir, trap, or other stationary contrivances used for the purpose of catching or obstructing the passage of fish in that part thereof where the fish are usually taken, the netting at the mouth of the same shall be floated to the surface of the water so as to effectually close the mouth thereof during the weekly close-time, so that during said time the fish may have a free, unobstructed passage, and no device shall be placed in any part of said limits which shall tend to hinder such fish from running up the waters of such rivers. In case the inclosure where the fish are taken is furnished with a board floor, an opening three feet wide shall be made extending from the floor to the top of the weir, trap, or other contrivances: *Provided, however*, that nothing herein shall be so construed as to apply to the shad and herring fisheries in the tributaries of Narragansett bay.

SEC. 35. The Commissioners of Inland Fisheries shall have a general supervision of all matters relating to the subjects contained in sections eight, ten, twenty-six, twenty-seven, and thirty-four of this chapter, and may make all needful regulations to carry out the provisions of said sections, and shall from time to time examine all the weirs, traps, or other contrivances, with a view of carrying out such regulations as are most beneficial to the people of the state, and shall prosecute for the violation of such regulations or for the infringement

of the provisions of any of said sections. They may co-operate with the fish commissioners of other states, and shall make an annual report to the general assembly of their doings, with such facts and suggestions in relation to the object for which they are appointed as they may deem proper. Said commissioners shall be allowed their actual disbursements made in the execution of this chapter.

Sec. 36. Every person who shall violate any of the regulations made by said commissioners under the authority of the provisions of the preceding section of this chapter, or who, during the close-time mentioned in section thirty-four, shall set any weir, trap, or contrivances contrary to such provisions, shall be fined not exceeding one hundred dollars or be imprisoned not exceeding three months, or both, in the discretion of the court before which the offender shall be tried.

Sec. 37. All forfeitures under this chapter shall, where there is no other provision made to the contrary, enure one-half thereof to the use of the town where the offence shall be committed and one-half thereof to the use of the person suing for the same.

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## CHAPTER 172.

*Of the Fishery of Pawcatuck River.*

Section 1. No weir or pound or other obstructions shall be erected or continued in the channel of Pawcatuck river, dividing the states of Rhode Island and Connecticut, so as to interfere with the main channel of said river, upon penalty of twenty dollars for the first offence, and seven dollars for every twenty hours or any less space of time any such weir or other obstruction shall be continued in the main channel of said river after the first offence.

Sec. 2. No weir or pound shall be erected or continued upon any flat or other part of the bottom of said river, eastward or westward of the aforesaid channel of said river, between the first day of June and the twentieth of March, annually, upon penalty of fourteen dollars for the first offence and seven dollars for every succeeding day such weir or pound shall be continued in said river, from the first day of June to the twentieth day of March, annually.

Sec. 3. No person shall fish with mesh or scoop nets in Pawcatuck river, or any of its branches, after sunset on Friday until sunrise on Monday in each week, from the twentieth day of March to the first day of June, annually, and no person shall use more than one net at a time upon penalty of five dollars for every offence.

Sec. 4. All penalties incurred for violation of any of the provisions of this

chapter shall enure one-half thereof to the use of the complainant and one-half thereof to the use of the town where the offence is committed.

Sec. 5. The foregoing provisions of this chapter shall be considered as forming a compact with the state of Connecticut, from which the general assembly will not depart until the legislature of the state of Connecticut shall agree with the general assembly of this state to a repeal thereof, alterations therein, or additions thereto.

Sec. 6. If any owner of land adjoining Pawcatuck river in this state shall permit any weir, pound, or other obstruction to be erected or continued upon any flat or bottom of said river, whether done, erected, or continued by himself, servant, lessee, or any other person, by his privity or consent, such owner shall be liable for any such breach or violation of section two of this chapter in the same manner as though the same had been committed by such owner in person.

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## CHAPTER 174.

*Of the Inland Fisheries.*

Section 1. The governor shall appoint seven commissioners of inland fisheries, who shall hold their offices for three years and until their successors are appointed.

Sec. 2. The Commissioners of Inland Fisheries shall introduce, protect, and cultivate fish in the inland waters of the state, and may make all needful regulations for the protection of such fish, and shall prosecute for the violation of such regulations and of the laws of the state concerning inland fisheries. (They may, in their discretion, from time to time make experiments in planting, cultivating, propagating, and developing any and all kinds of shell fish; and for the purpose of so doing may from time to time take, hold, and occupy, to the exclusion of all others, in one or more parcels, any portions of the shores of the public waters of the state, or land within the state covered by tide-water at either high or low tide not within any harbor line, and which is not at the time of such taking under lease as a private and several oyster fishery: *Provided,* that the land so held and occupied at any one time shall not exceed three acres. Said commissioners upon taking such land shall forthwith give public notice thereof by advertisement in some newspaper in the county in which said land is situated, which advertisement shall contain a description of said land; they shall also forthwith notify the commissioners of shell fisheries of such taking and shall transmit to them a description of said land, and shall also take out or otherwise mark the bounds of said land. Said commissioners may make all

needful regulations for the protection of the land so taken, and of all animal life and other property within the lines thereof, and shall prosecute the violations thereof.) They may co-operate with the fish commissioners of other states, and they shall make an annual report to the general assembly of their doings, with such facts and suggestions in relation to the object for which they were appointed as they may deem proper. Said commissioners, whenever complaint is made by them, or either of them, for a violation of any regulation made by them as aforesaid, or for violation of any of the provisions of this chapter or of chapters 171, 172, and 173, shall be not required to enter into recognizance on such complaint or become liable for costs thereon.

SEC. 3. The said commissioners shall cause a copy of any regulation made under the authority of the preceding section to be filed in the office of the town clerk of any town in which any waters stocked with fish, or land occupied for experiments under the authority of the preceding section and to which such regulations may apply, may be, and shall also cause a copy of such regulations to be advertised in some newspaper published in the same county.

SEC. 4. Every person who shall violate any of the regulations made by the commissioners of inland fisheries under the authority of the provisions of the preceding three sections, or who shall take any fish, fish-spawn, or any apparatus used in hatching or protecting fish, from any pond, lake, river, or stream stocked with or set apart by said commissioners, or by private parties, for the protection and cultivation of fish with the consent of the town council of the town where such cultivation is carried on, without the consent of such commissioners, or, if the cultivation of fish be carried on by a private party, without the consent of the person cultivating the same, or who shall trespass within the boundaries of any land which may be taken and occupied by said commissioners for their experiments in relation to shell-fish, authorized by section two of this chapter, shall be fined not exceeding three hundred dollars or be imprisoned not exceeding six months, or be both fined and imprisoned in the discretion of the court before which the offender shall be tried.

SEC. 5. Every person who shall catch any fish or shall use any seine for catching fish within half a mile from the mouth or outlet of any fishery set apart as is herein provided, and within any waters into which the waters of such fishery are let out, and every person who shall violate any of the provisions of sections seven, eight, and ten of this chapter, shall forfeit for the first offence the sum of fifty dollars, and for every subsequent offence shall forfeit one hundred dollars; and in addition to the penalties herein provided shall forfeit all the apparatus by him used in violation of the provisions of this section.

SEC. 6. Each of the commissioners of inland fisheries may, personally or by deputy, seize and remove, summarily if need be, all obstructions erected to

hinder the passage of migrating fish, or which are illegally erected to obstruct or in any way to impede the growth and culture of fish.

SEC. 7. No person shall take or catch fish of any kind from any of the inland waters of the state, set apart by the commissioners of inland fisheries for the cultivation of fish, except at such times and in such manner as is hereinafter provided.

SEC. 8. The prohibition of the catching of fish by hook and line, from fisheries stocked as hereinbefore provided, shall extend and be continued for and during the term of three years from and after the time when such fishery was first established: *Provided, however*, that fish may be caught through the ice only, and with hook and hand-line only, in those ponds set apart for the cultivation of black bass, during the months of December, January and February, until the expiration of the aforesaid term of three years.

SEC. 9. After the expiration of said three years no black bass shall be taken in any waters of this state, except Sneach pond in the town of Cumberland, and Moswansicut pond in the town of Scituate, between the first day of March and the first day of July in each year, nor at any time except by hook and line as aforesaid. Every person taking any black bass during the time aforesaid, or in any other manner except by hook and line, shall be fined fifteen dollars for each black bass so taken, and every person who shall take or have in his or her possession any black bass less than eight inches in length at any time of the year shall be fined fifteen dollars for each black bass found in his or her possession; and possession by any person of any black bass less than eight inches in length, or during the time aforenamed, shall be evidence that such black bass were taken in violation of this chapter; but nothing herein contained shall be so construed as to prohibit the taking and sale of black bass artificially cultivated in private ponds at any season of the year.

SEC. 10. After the expiration of said three years no fish shall be taken by any person from any waters legally set apart by said commissioners for the cultivation of shad or salmon, or within one mile of the outlet of the streams so set apart, except from and after the fifteenth day of April until the fifteenth day of July, or at any time except by hook and hand-line, or by not less than three-inch mess nets or seines.

SEC. 11. One-half of the fines and forfeitures recovered for violation of the provisions of this chapter shall accrue to the complainant and one-half thereof to the use of the state.

SEC. 12. The commissioners of inland fisheries may take fish from the fisheries hereinbefore referred to, for any purpose connected with fish culture or for scientific observation.

SEC. 13. Each of said commissioners may, in the discharge of his duties,

enter upon and pass over private property without rendering himself liable in an action of trespass.

SEC. 14. The commissioners of inland fisheries shall be allowed their actual disbursements made in carrying into effect the provisions of this chapter.

## CHAPTER 175.

*General Provisions for the Protection of Fisheries.*

SECTION 1. Every person who shall throw into or deposit in, or cause to be thrown into or to be deposited in, any of the public tide-waters of the state or upon the shores of any such tide-waters any fish-offal or any water impregnated with fish, unless the same be filtered in such manner as may be determined by the town council of the town wherein such deposit shall be made, and every person who shall cause any deleterious substance resulting from the smelting or manufacture of copper or from other manufactures, or from other sources, which is destructive to fish or which repels them from coming into the said public waters, or which shall do anything which tends to drive them therefrom, to be emptied, deposited, or run into the said public waters, shall forfeit one hundred dollars.

SEC. 2. Every vessel, craft, boat, or floating apparatus employed in the procuring of fish-oil, or in the dressing of bait for the mackerel fisheries, or the dressing of fish for other purposes, in violation of this chapter, shall be liable for any forfeiture and costs resulting from prosecution hereunder; and the same may be attached on the original writ and held, as other personal property attached may be held, to secure any judgment which may be recovered in any action brought to enforce any such forfeiture; and any person, upon view of any offence in violation of this chapter, may seize and detain any vessel, craft, boat, or floating apparatus, the same to be detained for a period not exceeding six hours.

SEC. 3. Every person who shall boil any menhaden fish, or press any fish for the purpose of extracting oil therefrom, on board of any vessel on any of the public tide-waters, shall be fined not exceeding fifty dollars.

SEC. 4. Any person who shall wilfully place any brush, trees, or limbs of trees in any of the waters of Charlestown pond shall be fined not more than twenty dollars nor less than five dollars for each offence; and all fines under this section shall enure one-half thereof to the use of the complainant and one-half thereof to the use of the town of Charlestown.

# PUBLIC LAWS.

## CHAPTER 969.

AN ACT IN SUBSTITUTION OF CHAPTER 857 OF THE PUBLIC LAWS, PASSED AT THE JANUARY SESSION, A. D. 1901, ENTITLED "AN ACT FOR THE BETTER PROTECTION OF THE LOBSTER FISHERIES."

SECTION 1. Every person who catches, takes, or has in his or her possession any lobster less than nine inches in length, measuring from the end of the bone projecting from the head to the end of the bone of the middle flipper of the tail, the lobster extended on its back its natural length, and every person who has in his or her possession any cooked lobster less than eight and three-quarters inches in length, and every person who has in his or her possession any female lobster bearing eggs or from which the eggs have been brushed or removed, shall be fined five dollars for every such lobster; but a person catching or taking any such live lobster and immediately returning the same alive to the water from which taken shall not be subject to such fine. The possession of any such lobster, cooked or uncooked, not of the prescribed length, shall be *prima facie* evidence to convict.

SEC. 2. All lobster pots, cars, and other contrivances used for the catching or keeping of lobsters shall be plainly marked with the name or names of the owner or owners. And every person who shall not have his lobster pots, cars, or other contrivances so marked shall be fined twenty dollars and be imprisoned not more than thirty days for each such offence. And all pots, cars, and other contrivances used contrary to the provisions of this section shall be seized by the officer engaged in the enforcement of this law, and said property shall be forfeited.

SEC. 3. There shall be, between the fifteenth day of November and the fifteenth day of April next succeeding, a close-time, during which time it shall be unlawful for any person to set or keep, or cause to be set or kept, within any of the waters of this state, any pots or nets for the catching of lobsters, or to take any lobsters during such close-time. Every person violating any of the provisions of this section shall be fined twenty dollars and be imprisoned not more than thirty days for each such offence.

Sec. 4. No person shall be allowed to set or keep, or cause to be set or kept, within any of the waters of the state, any pots or nets for the catching of lobsters who has not had his home and residence in this state for the period of one year next preceding the time of his catching such lobsters. Every person violating any of the provisions of this section shall be fined twenty dollars and be imprisoned not more than thirty days for each such offence.

Sec. 5. Every person, except the commissioners of inland fisheries and their deputies, who shall lift or raise any pot or net set for the catching of lobsters, without the permission of the owner or owners thereof, shall be fined ten dollars for each such offence.

Sec. 6. Every person who mutilates a lobster by severing its tail from its body, or has in his or her possession any such tail or tails of lobsters before such lobsters are cooked, shall be fined five dollars for each such offence; and in all prosecutions under this act the possession of any such tail or tails of uncooked lobsters shall be *prima facie* evidence to convict.

Sec. 7. The Commissioners of Inland Fisheries shall appoint at least two deputies, whose duties shall be the enforcing of the provisions of this act. Each of said deputies appointed as aforesaid shall be, by virtue of his office, a special constable, and as such deputy may, without warrants, arrest any person found violating any of the provisions of this act and detain such person for prosecution not exceeding twenty-four hours. Said deputies shall not be required to enter into recognizance or become liable for costs.

Sec. 8. For the purpose of enforcing the provisions relative to the protection of lobsters, the Commissioners of Inland Fisheries and their appointed deputies may search in suspected places, or upon any boat or vessel that they may believe is used in the catching or transporting of lobsters, and may seize and remove lobsters taken, held, or offered for sale in violation of the provisions of this act.

Sec. 9. Fines incurred under any of the provisions of this act shall enure one-half thereof to the use of the complainant and one-half thereof to the use of the state.

Sec. 10. The several district courts shall have concurrent jurisdiction with the common pleas division of the supreme court over all offences under this act, and to the full extent of the penalties therein specified; parties defendant, however, having the same right to appeal from the sentences of said district courts as is now provided by law in other criminal cases.

Sec. 11. Sections eight, nine, and ten of Chapter 171 of the General Laws, entitled "Of certain fisheries," and also Chapters 316 and 857 of the Public Laws, and all acts and parts of acts inconsistent herewith, are hereby repealed.

Sec. 12. This act shall take effect upon and after its passage.

## CHAPTER 1006.

### AN ACT IN RELATION TO TRESPASS ON LAND.

SECTION 1. Whoever shall enter upon the land of another for the purpose of either shooting, trapping, or fishing when the same shall be conspicuously posted by the owner or occupant with notices that shooting, trapping, or fishing is prohibited thereon, or whoever shall without right mutilate, destroy, or remove any such notice, shall be fined not exceeding twenty dollars.

SEC. 2. All acts or parts of acts inconsistent herewith are hereby repealed, and this act shall take effect July 1st, 1902.

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## CHAPTER 1132.

### AN ACT PROHIBITING THE TAKING OF FISH OF ANY SPECIES FROM THE WATERS OF GORTON'S LAKE, SO-CALLED, IN THE TOWN OF WARWICK, R. I., BEFORE APRIL 1, 1906.

SECTION 1. Every person who shall take fish of any species from the waters of Gorton's Lake, so-called, in the town of Warwick, before the first day of April, A. D. 1906, shall be fined not exceeding one dollar for the first offence, and not to exceed ten dollars for each subsequent offence.

SEC. 2. This act shall take effect immediately.

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## CHAPTER 1225.

### AN ACT IN ADDITION TO CHAPTER 171 OF THE GENERAL LAWS, ENTITLED "OF CERTAIN FISHERIES."

SECTION 1. Every person who catches or takes from any of the waters of this state or has in his or her possession any pickerel less than ten inches in length shall be fined five dollars for each such offence; but any person catching or taking any pickerel less than ten inches from any of the waters of this state and immediately returning the same alive to the water from which taken shall not be subject to such fine. The possession of any such pickerel not of the prescribed length shall be *prima facie* evidence to convict.

SEC. 2. This act shall take effect upon and after its passage.

# GENERAL SUBJECT INDEX

TO THE

# REPORTS OF THE COMMISSIONERS OF INLAND FISHERIES

OF THE

## STATE OF RHODE ISLAND.

## 1898-1907.

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# TITLES OF SPECIAL PAPERS PUBLISHED IN THE ANNUAL REPORTS OF THE COMMISSIONERS OF INLAND FISHERIES OF THE STATE OF RHODE ISLAND.

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1. Mead, A. D. The Starfish. (First paper.) Twenty-eighth Annual Report. 1898.
2. Mead, A. D. The Starfish. (Second paper.) Twenty-ninth Annual Report. 1899.
3. Tower, R. W. Improvements in the Methods of Preparation of Fish for Shipment. Twenty-ninth Annual Report. 1899.
4. Bumpus, H. C. The Extension of the Commercial Fisheries of the State. Twenty-ninth Annual Report. 1899.
5. Kellog, J. L. The Life History of the Common Clam. Twenty-ninth Annual Report. 1899.
6. Mason, N. R. A list of the Diatoms Found in the Water over the Clam, Mussel, and Oyster Beds in Narragansett Bay. Thirtieth Annual Report. 1900.
7. Mead, A. D. Observations on the Soft-shell Clam. Thirtieth Annual Report. 1900.
8. Mead, A. D. Observations on the Soft-shell Clam. (Second paper.) Thirty-first Annual Report. 1901.
9. Risser, J. R. H. Habits and Life History of the Scallop. Thirty-first Annual Report. 1901.
10. Mead, A. D. Habits and Growth of Young Lobsters and Experiments in Lobster Culture. Thirty-first Annual Report. 1901.
11. Mead, A. D. Observations on the Soft-shell Clam. (Third paper.) Thirty-second Annual Report. 1902.
12. Mead, A. D. Habits and Growth of Young Lobsters and Experiments in Lobster Culture. (Second paper.) Thirty-second Annual Report. 1902.
13. Mead, A. D. and Williams, L. W. Habits and Growth of the Lobster and Experiments in Lobster Culture. (Third paper.) Thirty-third Annual Report. 1903.
14. Mead, A. D. and Barnes, E. W. Observations on the Soft-shelled Clam. (Fourth paper.) Thirty-third Annual Report. 1903.
15. Mead, A. D. and Barnes, E. W. Observations on the Soft-shell Clam. (Fifth paper.) Thirty-fourth Annual Report. 1904.
16. Barnes, E. W. Preliminary Inquiry into the Natural History of the Paddler Crab (Callinectes hastatus) with Remarks on the Soft-shell Crab Industry of Rhode Island. Thirty-fourth Annual Report. 1904.
17. Mead, A. D. Experiments in Lobster Culture. (Fourth paper.) Thirty-fourth Annual Report. 1904.
18. Mead, A. D. Experiments in Lobster Culture. (Fifth paper.) Thirty-fifth Annual Report. 1905.

19. Hadley, P. B. Changes in Form and Color in Successive Stages of the American Lobster. Thirty-fifth Annual Report. 1905.

20. Emmel, V. E. The Regeneration of Lost Parts in the Lobster. Thirty-fifth Annual Report. 1905.

21. Tracy, H. C. A List of the Fishes of Rhode Island. Plates I–XII. Thirty-sixth Annual Report. 1906.

22. Tracy, H. C. The Common Fishes of the Herring Family. Plates VII–XII. Thirty-sixth Annual Report. 1906.

23. Barnes, E. W. Methods of Protecting and Propagating the Lobster, with a Brief Outline of its Natural History. Plates XIII–XXVI and XXVIII, XXXI, XXXII, XXXVI. Thirty-sixth Annual Report. 1906.

24. Hadley, P. B. Regarding the Rate of Growth of the American Lobster. Plates XXVI–XXXVII, and XL. Thirty-sixth Annual Report. 1906.

25. Hadley, P. B. Observations on Some Influences of Light upon the Larval and Early Adolescent Stages of Homarus Americanus. Plates XXXVIII–XL. Thirty-sixth Annual Report. 1906.

27. Emmel, V. E. The Relation of Regeneration to the Molting Process in the Lobster. Plates XL–XLI. Thirty-sixth Annual Report. 1906.

28. Tracy, H. C. The Fishes of Rhode Island, III: The Fishes of the Mackerel Family. Thirty-seventh Annual Report.

29. Tracy, H. C. A List of Rare Fishes taken in Rhode Island in the year 1906. Thirty-seventh Annual Report.

30. Williams, Dr. Leonard W. List of the Rhode Island Copepoda, Phyllopoda, and Ostracoda, with new species of Copepoda. Thirty-seventh Annual Report.

31. Emmel V. E. Regenerated and Abnormal Appendages in the Lobster. Thirty-seventh Annual Report.

32. Williams, L. W. The Stomach of the Lobster and the Food of Larval Lobsters. Thirty-seventh Annual Report.

33. Hadley, P. B. Regarding the Behavior of the Larval and Early Adolescent Stages of the American Lobster. Thirty-seventh Annual Report.

34. Barnes, E. W. Lobster Culture at Wickford, Rhode Island, in 1906. Thirty-seventh Annual Report.

35. Barnes, E. W. Lobster Culture at Wickford, Rhode Island in 1907.

36. Tracy, H. C. The Fishes of Rhode Island V. The Flatfishes.

37. Tracy, H. C. The Fishes of Rhode Island VI. A Description of two young Specimens of Squeteague (*Cynoscion regalis*) with Notes on the Rate of their Growth.

38. Emmel, Victor E. The Problem of Feeding in Artificial Lobster Culture.